CMFRI Special Publication
Number 3

SUMMER INSTITUTE IN

BREEDING AND REARING OF MARINE PRAWNS

Central Marine Fisheries Research Institute
P. B. 1912, COCHIN - 682018, INDIA

Indian Council of Agricultural Research

SUMMER INSTITUTE IN

BREEDING AND REARING OF MARINE PRAWNS

HELD AT

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

From 11 May to 9 June 1977

Director of the Summer Institute: *E.G.SILAS*

CMFRI SPECIAL PUBLICATION

Number 3

Central Marine Fisheries Research Institute

P. B. 1912, COCHIN - 682018, INDIA

Indian Council of Agricultural Research

March 1978

Published by: E. G. SILAS
Director
Central Marine Fisheries
Research Institute
Cochin 682018

Edited and Printed by: K. N. KRISHNA KARTHA
Scientist (Technical Cell)
Central Marine Fisheries
Research Institute
Cochin 682018

Contents

Foreword

Since 1967, the Indian Council of Agricultural Research has been sponsoring Summer Institutes in different disciplines of agricultural and animal sciences including fisheries. The main objectives of the Summer Institutes are to bring about the qualitative improvements and up date the teachers, research workers and extension subject matters specialists in the latest knowledge and techniques in the field of their specialisation, to provide necessary orientation to contemporary problems and to provide a common forum for co-professionals to interact and exchange experiences and to maintain a feedback to make research and education more relevant. These courses are usually organised during the summer vacation period, so that, the teaching work of the sponsoring Institutes does not suffer.

The Central Marine Fisheries Research Institute, Cochin, conducted the first Summer Institute in "Coastal Aquaculture" in 1974. The recently conducted summer Institute was the second in the series and was on the subject "Breeding and Rearing of Marine Prawns".

In recent years mariculture has been receiving increasing importance all over the world as a means of augmenting production; as an industrial enterprise for improving rural economy and as an operation for productive utilisation of the vast derelict and coastal waters. In India, there are extensive estuaries, backwaters, mangroove swamps and numerous lagoons all along the coastline suitable for culture operations. A variety of fishes and prawns ideally suitable for culture are also available. With these basic requirements as well as

large man-power, there is immense scope for the development and establishment of profitable prawn culture in the coastal zone.

The Central Marine Fisheries Research Institute has been undertaking several investigations in recent years to improve the existing culture practices in the country and to develop new indigenous techniques to establish prawn farming on scientific and modern lines. Considerable progress has been achieved in this direction. Integrated farming of Paddy-Prawn Culture and other systems are being undertaken. The Summer Institute in "Breeding and Rearing of Marine Prawns" was entirely manned by the Scientists of this Institute to descriminate the results obtained so far.

This publication presents the salient features of this Summer Institute and the background papers prepared as an aid to the lectures and practicals. It is hoped that this would be useful as a reference manual on the subject.

E. G. SILAS
Director, CMFRI.

Syllabus and members of faculty

SYLLABUS

THEORY

1. *Introduction to the course*
   Aims and objectives of the course — need for development and establishment of culture fisheries for prawns — prospects — plan of the course .. 1 hour

2. *General review of prawn culture*
   Historical background — review of prawn culture in India and abroad — species cultivated in different regions — area utilised — production trend and its contribution — National Plans .. 1 hour

3. *Taxonomy and distribution of cultivable prawns*
   Morphology — systematics — distribution .. 1:30 hours

4. *Features of prawns which contribute to their suitability for culture*
   Adaptability to different environmental conditions at different stages of growth — biological features such as high fecundity, fast growth rate, wide feeding habits — economical features such as high demand and price .. 1 hour

5. *Food and feeding of prawns*
Digestive system — natural food — feeding habits at different stages of growth .. 1 hour

6. *Growth*
Determination of growth — growth rates in different natural environs at different life stages — growth rates in culture fields — factors influencing growth — moulting phenomenon and growth .. 1 hour

7. *Maturation and spawning*
Reproductive system — maturation process — maturity stages — size at first maturity — fecundity and its relationship to size and weight — spawning seasons — spawning frequency — biological and environmental factors influencing maturation and spawning — harmonal control .. 1:30 hours

8. *Rearing of prawns under controlled conditions*
Equipments required — collection and transportation of spawners — breeding under captivity — techniques of rearing eggs, larvae and postlarvae — stocking size — food of larvae — identification of larvae .. 3 hours

9. *Seed production*
Prawn seeds from natural source — seed grounds — availability and abundance — methods of collection — production under controlled conditions — transportation of seeds — problems of mass production of seeds .. 2 hours

10. *Mass culture of phytoplankton*
Methods adopted for isolation of unialgal cultures — mass culturing techniques — problems and precautions in mass culturing — role of phytoplankton in rearing prawn larvae .. 1 hour

11. *Feeding larval and juvenile prawns in culture*

Culture of brine shrimp — culture of other zooplankters .. 1 hour

12. *Artificial feed*

Compounded feed for different stages — composition, properties, manufacture, application in large-scale culture .. 1:30 hours

13. *Prawn farm*

Classification of farms — selection of farm site — topographical requirements — water conditions — availability of seeds — construction of farms — engineering installations — preparation of fields for stocking and culture .. 2 hours

14. *Environmental requirements for the culture of marine prawns*

Bottom conditions — quality of water — requirements of salinity, temperature, oxygen, etc., and their influence on the survival and growth of prawns .. 1 hour

15. *Productivity of farm*

Standing crop measurements — oxygen and carbon-14 technique — factors affecting primary production .. 2 hours

16. *Prawn farming*

Traditional culture practices in India and in South-East Asian countries — Advantages and disadvantages of traditional practices — methods of increasing production — selective culture — monoculture — polyculture — diseases and their control — management of prawn farms .. 2 hours

17. *Harvesting and marketing of cultured prawns*
Appropriate size and time for harvesting — methods of harvesting — marketing of dead and live prawns .. 1 hour

Total .. 24:30 hours

PRACTICAL

1. *Identification of prawns* .. 5 hours

2. *Gut-content analysis*
Dissection of digestive system — examination of gut contents .. 3 hours

3. *Determination of maturity stages*
Dissection of reproductive system — macroscopical and microscopical observations to distinguish different maturity stages .. 3 hours

4. *Fishing and transportation of spawners*
Fishing for spawners — care of spawners — transportation of spawners to hatchery .. 12 hours

5. *Breeding and rearing experiments*
Observations on breeding — rearing of eggs, larvae and postlarvae — identification of larvae .. 48 hours

6. *Collection of prawn seeds from nature*
Collection of planktonic larvae — examination of prawn larvae in live condition — identification — seed collection from surf and backwaters .. 6 hours

7. *Culture of phytoplankton* .. 6 hours

8. *Preparation of artificial feeds*
Different types of ingredients — compounding of feeds .. 6 hours

9. *Productivity measurements* .. 12 hours

10. *Visit to prawn fields to observe the traditional culture practices* .. 6 hours

11. *Visit to local fisheries organisations* .. 6 hours

Total .. 113 hours

MEMBERS OF FACULTY

	Topics (*The number indicates the items as given under Syllabus*) Theory	Practical
Dr E. G. Silas, Director	1	
Shri M. S. Muthu, CMFRI, Cochin.	2, 8	4, 5, 6
Shri M. M. Kunju, Calicut Research Centre of CMFRI.	3, 6	1
Shri N. Surendranatha Kurup, CMFRI, Cochin.	4	6
Dr M. M. Thomas, CMFRI, Cochin.	5, 12	2, 8
Dr P. Vedavyasa Rao, CMFRI, Cochin.	7	3, 11
Shri N. Neelakanta Pillai, CMFRI, Cochin.	9	4, 5, 6
Shri R. S. Pandey, Prawn Culture Laboratory, Narakkal.	10	4, 5, 6
Dr C. Marrylal James, Prawn Culture Laboratory, Narakka	11	4, 5, 6
Dr S. Ramamurthy, Mangalore Research Centre of CMFRI.	13	—
Shri C. Suseelan, CMFRI, Cochin	14	1, 3, 6

Dr. P. V. Ramachandran Nair, CMFRI, Cochin.		7, 9
Shri C. P. Gopinathan, CMFRI, Cochin.	15	
Shri V. K. Balachandran, CMFRI, Cochin.		
Shri K. V. George, CMFRI, Cochin.	16	4, 5, 6, 10
Shri M. Kathirvel, CMFRI, Cochin.	17	1, 2
Dr M. Narayanan, Prawn Culture Laboratory of CMFRI, Narakkal.		4, 5, 6
Miss Suryakumari, Prawn Culture Laboratory of CMFRI, Narakkal.		5, 6
Miss R. Cherian, Prawn Culture Laboratory of CMFRI, Narakkal.		5, 6
Shri K. N. Gopalakrishnan, CMFRI, Cochin.		6
Shri K. N. Rasachandra Kartha, CMFRI, Cochin.		4, 5, 6

Participants

1. Shri Mohamed Syed Faheem, Project Officer, Andhra Pradesh Fisheries Corporation Ltd., Kakinada 2, Andhra Pradesh.
2. Shri M. I. Patel, Senior Research Assistant, Dept. of Fisheries, Govt. of Gujarat.
3. Shri Y. A. Trivedi, Assistant Research Officer, Dept. of Fisheries, Govt. of Gujarat.
4. Shri P. B. Tandel, Assistant Supdt. of Fisheries, Dept. of Fisheries, Govt. of Karnataka.
5. Shri B. Venkatesh, Instructor in Fish Culture, University of Agricultural Sciences, College of Fisheries, Mangalore, Karnataka State.
6. Shri K. S. Joseph, Research Officer, Dept. of Fisheries, Govt. of Kerala.
7. Shri P. C. John, Lecturer in Zoology, C.M.S. College, Kottayam, Kerala State.
8. Shri P. Karunakaran Nair, Senior Technical Assistant, Krishi Vigyana Kendra of the Central Marine Fisheries Research Institute, Narakkal, Cochin.
9. Dr S. Kulasekara Pandian, Scientist, Central Marine Fisheries Research Institute, Cochin.
10. Shri P. Muthiah, Scientist, C.M.F.R. Institute, Cochin.
11. Shri A. V. Kulkarni, Fisheries Training Officer, Dept. of Fisheries, Govt. of Maharashtra.
12. Shri K. M. S. Ameer Hamsa, Scientist, C.M.F.R. Institute, Cochin.
13. Shri V. Ramaiyan, Research Associate, Annamalai University, Centre of Advanced Study in Marine Biology, Parangipettai, Tamil Nadu.

14. Shri S. Shanmugam, Scientist C.M.F.R. Institute, Cochin.

15. Shri V. Venkatesan, Senior Research Assistant, Dept. of Fisheries, Govt. of Tamil Nadu.

16. Shri M. Sivaraman, Sub-Inspector of Fisheries, Dept. of Fisheries, Govt. of Pondicherry.

Proceedings of the Summer Institute:

a brief summary

The Summer Institute in "Breeding and Rearing of Marine Prawns" was held at the Central Marine Fisheries Research Institute at Cochin during 11 May — 9 June 1977. The Summer Institute was inaugurated by the Director, Dr E. G. Silas, at a function attended by the participants, members of faculty and other scientists of the Institute, at 11 AM on 11 May 1977. Following this, the daily schedule, consisting of lectures in the forenoon and practicals in the afternoon, commenced with an introductory lecture by the Director.

The course offered during the first week was to introduce the participants to the relevant aspects of taxonomy, biology and ecology of cultivable species of marine prawns. In the second week, intensive training was given in identification, collection and transport of spawners, breeding them in the laboratory and in rearing of eggs and larvae under controlled conditions. The participants were grouped for this purpose into four batches and each batch was taken on board, for the collection of spawners. They then stayed overnight at the prawn-culture laboratory at Narakkal for observing the breeding. Preparation of artificial feeds, culture of phytoplankton and other food organisms were demonstrated to the participants and were also undertaken by them during this week.

Various aspects of commercial prawn farming were discussed and were demonstrated during the third week when

the participants were taken to the important prawn farms and fishery organisations located in and around Cochin.

Towards the end of the course, a group discussion was organised, which was presided over by Shri K. H. Mohamed, FAO Expert. The participants explained briefly the prospects and status of prawn culture in their respective states and pointed out the various problems encountered. They stated how the experience gained from the training would be utilised for the improvement of prawn culture in their respective states.

An evaluation test was given to the participants on 8 June.

The valedictory function of the Summer Institute was held on 9 June in the Conference Hall of the Bharat Tourist Home, Cochin. The function was presided over by Shri S. G. Sundaram IAS, Chairman, Marine Products Export Development Authority. Shri R. Madhavan Nair, pioneer of shrimp export industry in India, was the Chief Guest. The function was attended by a large gathering including Heads of Central and State Fisheries organisations, fishery industrialists and scientists. The Chief Guest distributed the certificates to the participants.

All the participants evinced keen interest in the course in which they took active parts. From the views expressed by them at the end of the course, it was evident that with the knowledge acquired by them during the training, they became more confident to undertake intensive prawn culture in their respective states.

Background papers

1

RESEARCH AND DEVELOPMENT PROGRAMMES IN THE CULTURE AND PROPAGATION OF MARINE PENAEID PRAWNS

by
E. G. Silas

INTRODUCTION

The Research and Development programmes on marine fisheries of the country have been greatly weighted towards the development of the capture fisheries involving the traditional small-scale fisheries as well as the rapidly developing industrial fisheries. However, the trend of growth in marine capture fisheries has not kept the anticipated annual increment on account of large-scale fluctuations in some of our major fisheries. This picture is not very different from that of the world marine fish production which has been stagnating around 69 million tonnes during the last two-three years. In this context the present global effort in finding ways and means to augment world fish production through coastal aquaculture including mariculture is very pertinent. This has given a boost to marine finfish and shellfish culture in the coastal and contiguous brackish waters in many parts of the world. In India, coastal aquaculture carried out by traditional methods in the brackish waters accounts for hardly 1% of the annual fish production. But it offers considerable scope for improvement through planned scientific methods.

One of the major objectives of the Central Marine Fisheries Research Institute has been to find ways and means of augmenting our marine fish production. In this context, the research and development in coastal aquaculture has figured prominently in the Institute's programmes during the latter half of the Fifth Five Year Plan. Along with various components of finfish and shellfish investigations, the Institute has endeavoured to develop indigenous techniques of culture and to work out the techno-economic feasibility of culture operations of certain cultivable marine species. On the basis of the results of these investigations, pilot projects are now being taken up to find out the economic viabiliy of large scale farming.

PENAEID PRAWN CULTURE

Significant break-through in the culture of marine penaeid prawns has been achieved by successful spawning, rearing, stocking and harvesting of some of the commercially important species occurring along the southwest and southeast coasts of India. Considerable amount of this work has been carried out at the prawn culture laboratory and farm of the Institute at Narakkal from 1974 under the scheme "Culture and Propagation of Marine Prawns". Within a short period after the establishment of a full-fledged field laboratory at Narakkal in September 1975, it has been possible to successfully spawn and rear penaeid prawns such as *Penaeus indicus, P. monodon, Metapenaeus monoceros, M. affinis, M. dobsoni,* and *Parapenaeopsis stylifera.*

Concurrently, research has been intensified for finding suitable feed for the larvae at different stages of development. Techniques of mass culture of suitable phytoplankters for the early stages of protozoea and mysis of prawns, and brine shrimp (*Artemia salina*), rotifers and mysids for the late mysis and postlarval stages, have been developed. The culture of food organisms under controlled conditions has not only involved development of suitable media for the maintenance of continuous and large-scale production of phytoplankters such as the species of *Thalassiosira, Chlorella* and *Skeletonema,* but also feed for enabling the mass culture of zoo-

plankters. This has also helped in improving the survival rates of penaeid prawn larvae up to stocking size, in some cases as in *M. dobsoni* up to 40% or more.

The brackish waters adjacent to the coast, backwaters, mangrove swamps, estuaries, and the surf area are all known to be good grounds for collecting prawn seed. The Institute has located several such areas in the course of the seed resources surveys being carried out in some of our maritime states. However, the availability of prawn seed in wild highly fluctuates not only seasonally, but also in the species composition. Hence complete reliance on seed from wild will not be possible, when we think in terms of large-scale prawn culture involving several thousand hectares of water areas. The solution will be the large-scale production of prawn seed under controlled conditions and the ultimate domestication of desirable species. Though the basic know-how on how this could be achieved is available with the Institute, there are still several areas, constraints and gaps to be filled in, which need intensive research for streamlining the techniques.

In the course of this Summer Institute training, you are going to be taught all that the Institute has done to promote large-scale culture of marine prawns. You will also see that prawn culture is not all that simple as it would appear, but involves several inputs which have to be properly administered to make the venture economically successful. This could start from the selection of site, construction of bunds, proper disposition of sluices, maintenance of the productivity of the waters, eradication of the undesirable species, availability of seed for stocking and so on. Ecological conditions, the tidal amplitude and the amounts of flood waters which flush the brackish water areas differ from place to place and make it difficult for a package prawn-culture plan to be made applicable countrywide. In other words, certain aspects such as farm engineering problems are location-specific, calling for different strategies to be adopted in different regions.

SEASONAL USE OF SALT PANS FOR PRAWN CULTURE

The Institute has tried to see how best inundated coastal tracts, salt pan reservoirs and coastal derilict waters could be used for prawn culture. Encouraging results have been ob-

tained both at Tuticorin as well as at Kakinada with species such as *P. indicus* and *P.monodon* cultured during the monsoon season in the salt pans.

POLYCULTURE OF PRAWNS AND FISHES

Polyculture of *P. indicus, M. dobsoni* and other species of prawns along with *Chanos chanos, Mugil* spp. and *Etroplus suratensis* has given very encouraging results and will eventually be adopted in large scale in the commercial farms with additional species such as *P. monodon* and *P. merguiensis* among prawns.

The culture of postlarval penaeid prawn spawned and reared under controlled conditions as well as prawn seed collected from the wild has shown that after stocking at about 2 to 3 cm size along with fingerlings of milkfish, mullets and *Etroplus*, the prawns have attained marketable size (*P. indicus* from 13 to 15 cm weighing 15 to 20 gm; *M. dobsoni* from 8 to 9 cm weighing about 8 gms) within 10 to 12 weeks in perennial fields. Fishes, particularly *Chanos* have also shown excellent growth from 4 cm to about 40 cm during this period.

Despite some rapid strides made in the R & D programmes in prawn culture at the Institute as well as by other organisations such as the Central Inland Fisheries Research Institute, the ICAR All-India Coordinated Research Project on "Brackish Water Fish farming" at Kakdeep and Madras. Konkan Krishi Vidyapeeth at Ratnagiri and the Department of Fisheries, Tamil Nadu, there are large gaps in our knowledge which need priority attention. So also there are new areas and systems to be worked out to make marine prawn culture more meaningful in the context of our integrated rural development efforts as well as to meet the demands of the capital-intensive ever-expanding export-oriented industry. I would like to highlight some of these areas which require special attention.

1. *Biology of penaeid prawns*

We have accumulated a considerable amount of data on the biology of most of our commercially important species of

penaeid prawns. However, there are still gaps in our knowledge of reproduction biology, physiology, endocrinology, food and feeding habits, growth, survival, migration and behaviour of some species.

2. *Large-scale prawn seed production*

Our dependence on collection of prawn seed from the wild will in the near future have to be replaced by production of prawn seed under controlled conditions. The techno-economic feasibility of carrying out large-scale production of seed has been studied for some species, but a lot of research is still needed in improving the survival rate at various stages from hatching to stocking size, the rematuration of spent prawns and ultimately the domestication of some of our commercially important species. The development of any large-scale hatchery system by itself needs several technological inputs which will have to be tailored to keep the economics of large-scale seed production at a minimum cost.

3. *Feed technology and nutritional physiology*

a) *Live food organisms*

A variety of live food is necessary for the successful rearing and culture of prawns from larval stage onwards. While the Institute has carried out successful trials with such as phytoplankters and zooplankters including *Artemia* mysids and rotifers, techniques of large-scale culture of these food organisms need perfection.

b) *Artificial feed*

This is a weak-link and needs considerable amount of research for developing suitable compounded artificial feed for some of the larval stages as well as prawns cultured in the farm. Nutritional requirements vary from species to species and capsulation of suitable feed particularly for undertaking culture operations in less productive waters needs priority attention. The ecological energetics of the various commercially cultivable species will have to be studied under actual field conditions for a better appreciation of their nutritional requirements.

4. *Improvement of stock*

Practically no work has been done in this direction. It is also not known at this stage to what extent prawn stocks differ genetically along their spatial range of distribution.

5. *Polyculture of species of prawns and finfish*

For the proper utilisation of the water area, suitable combinations of prawns and finfish will have to be selected for various areas. While at present we have some information on the compatibility of culture of penaeid prawns along with the finfishes such as *Chanos chanos*, *Mugil* spp. (*Mugil cephalus*, *M. macrolepis*) and *Etroplus suratensis*, the optimum number of stocking in different field conditions and types along the coast, and culture of other non-competing species for food and space need further investigations. The feasibility of culturing food organisms such as clams in the same area so that they could be harvested in small quantities and the meat fed to the prawns will also need special attention from the point of view of effecting overall economy in the culture operations.

In polyculture it is also likely that harvesting of finfish and prawns may not be carried out at the same time. Proper scheduling of harvesting at different periods with restocking of component species in commercial operations may have to be worked out.

6. *Parasites and diseases*

Little information is available on this aspect, and in intensive prawn culture, serious attention will have to be paid to monitor the stock for early detection of any disease or infestation with external or internal parasites. Observations at the Narakkal farm clearly indicate that Vibrio and other bacterial infestations do occur in prawns resulting in mortality.

7. *Chemistry of water, soil conditions and pollution*

Continuous monitoring of the quality of water as well as soil conditions for its nutritive value and other characteristics is necessary in large-scale prawn culture operations. Many of

our coastal areas are subject to pollution of various types which necessitate suitable monitoring system to be developed for checking the quality of the water periodically. The technical know-how for such monitoring may not be available at the fish farmers level, but training in this field may have to be extended and simple kits developed for easy detection of pollutants.

8. *Farm engineering*

Problems relating to farm engineering will be location-specific, especially as the ecological conditions, tidal amplitude, and the influx of flood waters, vary from place to place. The tidal amplitude is considerable in the northern maritime states such as Gujarat and Maharashtra as compared to Kerala. The engineering problems connected with the construction of ponds, the type of sluices to be fabricated and provided, will also vary necessitating quite a lot of research inputs into farm engineering problems.

9. *Methods of harvesting*

It is well known that harvesting with conventional gears such as seine nets, cast nets and so on will not help to remove all the prawn which may be available in the stocked pond. In fact, fishing is carried out over 2 or 3 days to remove the bulk of the quantity of prawns stocked. A harvesting technology for enabling capture of prawns in a single operation from the ponds should be developed so that the labour-cost inputs on harvesting could be minimised.

10. *Farm management*

Coastal aquaculture is a new development in this country and as such trained manpower for the proper management of the farm hardly exists. Farm management is an important area which cannot be neglected if large-scale intensive culture operations are to be undertaken.

11. *Integration of crop|live stock finfish and shellfish culture*

Since our rural life is linked up with more than one system, suitable integrated programmes of crop|live stock|fish

and prawn culture should be developed to maximise production outputs and benefits. At present hardly any scientific input has gone into such a system involving coastal aquaculure.

12. *Training of personnel and extension*

Training needs are varied and have to be imparted at different levels. Training of fish and prawn farmers as at present being imparted by the Krishi Vigyan Kendras may suffice. For technical personnel, training has to be given at higher levels. The Central Marine Fisheries Research Institute has been running training courses in prawn culture through its Krishi Vigyan Kendra for mariculture to the fish farmers and also other courses for the technical personnel from the maritime states and personnel from other countries. Such training programmes are to be strengthened and also where necessary subject matter - specific training be imparted at different centres.

Extension of the known technology has been a very poor link in the development programmes. For having a proper area-wise, or regional impact of the research results, the tansfer of technology has to be carried out through well developed extension programmes. Strengthening of this area needs priority attention.

13. *Legal aspects*

Large-scale prawn culture operations will lead to legal complications where traditional fishing rights exists; where sharing of waters from a common source is needed; where navigational rights have to be protected; where right of way over bunds exists; where reclamation of land farm is carried out and so on. Scientific background information may be necessary in some cases for formulating any Act or Legislations.

14. *Socio-economics*

No special studies on the socio-economic conditions where traditional coastal aquaculture practices are carried out at present have been made. Comprehensive Surveys may have to be organised in order to measure the impact of improved

technology in farming practices in areas where traditional prawn culture practices are in vogue or where such operations have been taken up in an integrated manner for improvement of socio-economic conditions of the farming community.

In addition to these, there may be several aspects which need our immediate attention. At this Summer Institute you are going to be shown and taught whatever has been done at this Institute. We would like each one of you to follow the Summer Institute Training by developing similar techniques with suitable modifications for culture of prawns in your areas. We would also like to see such training included in the syllabus, where fishery science forms a part of the curriculum. The theoretical aspects of the course have been kept down to the minimum to enable you to have the maximum amount of practical training possible during the period of this Summer Institute.

2

A GENERAL REVIEW OF PENAEID PRAWN CULTURE

by
M. S. Muthu

In the Indo-Pacific region prawn culture in coastal brackishwater ponds and impoundments has been practised for five centuries or more. The penaeid prawns belonging to the genera *Penaeus* and *Metapenaeus* spawn in the sea but the postlarvae enter the estuaries and backwater areas in large numbers and grow rapidly. These areas serve as natural nurseries for the juveniles. The euryhaline nature of these prawns enables them to colonize the estuaries and backwaters. In the traditional culture operations these naturally occuring postlarvae and juveniles are trapped in tidal impoundments and allowed to grow for short periods before they are caught. These ponds are constructed in suitable coastal brackishwater

areas where there is a good tidal range and an abundant supply of prawn seed.

In India this type of prawn culture is practised in the brackishwater *bheris* of West Bengal and in the paddy fields adjoining the Vembanad lake in Kerala. Because of the uniqueness of the paddy field prawn culture in Kerala it is briefly reviewed here. About 4500 hectares of low-lying coastal areas in the districts of Ernakulam, Alleppey and Trichur are utilized for growing paddy during the southwest-monsoon season and prawns during the rest of the year. The fields are connected by canals to the Vembanad lake and are subjected to tidal influence. During the southwest-monsoon season the heavy precipitation makes the waters of the Vembanad lake almost fresh and the paddy fields are also inundated by fresh water. During this period (June-September) a special variety of paddy called "Pokkali", which is tolerant of salinities up to 6-8 ppt, is grown in these fields.

After the paddy is harvested the fields are leased out to prawn culturists from October to April-May. During this period the salinity of the water in the feeder canals increases and so paddy cannot be grown. The bunds and sluices are repaired. The paddy stumps are not cut but allowed to decay in the water to form a good organic manure that stimulates the growth of phytoplankton and zooplankton. The decaying paddy stalks form detritus and also provide a good substrate for the growth of periphyton. The juveniles of marine prawns and fish that are found naturally in the backwater system enter the fields along with the tidal water. They feed on the rich detritus, periphyton and plankton and grow rapidly. During low tide the prawn and fish are prevented from escaping from the fields by placing bamboo screens in the sluices. After stocking in the fields for about a month fishing starts in December and continues till April-May. Fishing is done at night or in the early morning during low tide for 6-8 days around the new-moon and full-moon phases, by placing a net at the mouth of the sluice. The prawn catch from the fields varies from 500-1200 kg per hectare for the 6-month period.

At the end of the lease period (April-May) the fields are handed over to the owners for paddy cultivation. During this

period the low-tide level happens to be very low and the fields are left with very little water. When the tide reaches the lowest level the sluices are completely closed and the water from the canals is not allowed to enter the fields. The soil is gathered into small heaps. With the first few heavy monsoon rains the salt in the soil is leached out and the water that collects in the depressions surrounding the soil heaps may be pumped out. With further rains even the water in the canals becomes almost fresh. The seeds are sown on the heaped soil. When the seedlings have grown to transplantable size they are removed and after levelling the heaps, transplanted again. "Pokkali" is a short-term crop and is ready for harvest in 90-100 days.

The local farmers should be applauded for evolving this ingenious method of rotation of crops. The natural changes in the ecosystem are so beautifully adopted for man's use that this practice of growing paddy and prawns in the same field in successive seasons has been well established as a lucrative enterprise.

The coastal mangrove swamps have been converted into prawn ponds in Singapore, Malaysia, Thailand and Viet Nam. In Indonesia prawns are grown along with milkfish in the coastal brackishwater ponds called "tambaks".

Prawn culture as practised in India and the southeast Asian countries involving natural stocking in tidal enclosures is also called the extensive method of culture. Here the culture fields are extensive in area (up to 60 ha), there is no control over the number stocked, no supplementary food is given and the yield is also comparatively low.

The disadvantages of this method are:

(1) It is not possible to control the species composition or the density of population of prawns inside the ponds.

(2) The natural supply of seed fluctuates widely in species composition and abundance from year to year and hence the yield from the ponds is highly variable.

(3) The predatory fish that enter the ponds along with the prawn fry prey upon the prawns and drastically reduce the yield. However, because of the simplicity and inexpensiveness of this method of prawn culture, it is becoming popular even in Mexico, Ecuador, Cuba and U.S.A.

A more highly developed form of prawn culture which can be termed *Semi-intensive,* involves controlled stocking of earthern ponds (less than 5 ha in extent) cleared of all predatory organisms, with known number of prawn fry collected from the wild or produced artificially in hatcheries. Supplementary feed is also given. The yield is highly variable depending on the nature of the ponds, the fertilizers used, the food given and the species cultivated. The simplest form of semi-intensive prawn culture is practised in Philippines, where *Penaeus monodon* postlarvae collected from the estuaries are selectively stocked in brackishwater ponds along with milkfish or grown separately in monoculture. In India *P. indicus* and *P. monodon* are selectively stocked in salt pans at Manakkudy and Kakinada respectively.

A more advanced form of semi-intensive culture has been perfected in Japan, where *Penaeus japonicus* is made to spawn under controlled conditions and the larvae are reared on a very large scale in hatcheries up to the stocking size, the late postlarvae are stocked in disused salt pans and fed with crushed clams or trash fish. The prawns attain the harvestable size of 20 g in six months. Yields up to 2500 kg/ha have been achieved in these salt pans. This advanced form of commercial shrimp culture has been recently started in a small way in Korea and Taiwan. In the Philippines, Indonesia, India, Australia, Italy, Spain and France this type of culture is in the experimental stage.

In the most highly developed form of culture, all the stages from the egg to the harvestable size are grown under controlled conditions. The prawn fry raised in hatcheries are grown to marketable size in large cement tanks (up to 1000 m^2) with running sea water or in circular or rectangular concrete tanks (up to 800 m^2) fitted with false bottom and air-lift recirculating system. This method which can be termed the

intensive method of culture, is now being practised only in Japan. Very high stocking densities (up to 180 prawns/m ^{2}) are tried and the prawns are fed only with artificial feeds. Yields up to 22,000 kg/ha have been achieved in recirculating systems.

This intensive form of culture is naturally capital-intensive and the cost of production is very high. The highly developed prawn culture industry in Japan is able to maintain itself mainly because of the high price paid for the live prawns that are used to prepare *tempura,* a Japanese delicacy, served in luxury hotels.

In Table 1 the type of prawn culture practised in different countries of the world, the area under cultivation, the yield/ha, and the species cultivated are summarised.

TABLE 1.

Country	Area under cultivation (in hectares)	Yield/ha. (in Kg)	Total annual production (in tonnes)	Species cultivated
1	2	3	4	5
		Extensive prawn culture		
India (Kerala) (Nair *et al* 1975)	5,000	500-1200 kg per season	6,000	*P. indicus* *P. monodon* *M. dobsoni* *M. monoceros*
Indonesia (Alikunhi *et al* 1975)	182,073	47-69 per/year	85,000-12,500	*P. merguiensis* *P. monodon* *M. ensis*
Malaysia (Fisheries Division, Malaysia, 1973)	330	730-1220 per/year	246-408	*P. monodon* *M. ensis*
Singapore (Bardach *et al* 1972, Rabanal 1977)	465	300-800 per *year*	105	*P. indicus* *P. merguiensis* *M. brevicornis* *M. ensis* *M. burkenroadi*

1	2	3	4	5
Thailand (Sribhibhadh 1973)	7,825	250-900 per year	3,440	*P. merguiensis* *M. ensis*
U.S.A. (Rose *et al* 1975)	11	48.2-141.2 per year	—	*P. aztecus* *P. duorarum* *P. setiferus*
Vietnam (Dang, Le Van 1973)	1,000	200-250 per year	—	*Penaeus* spp. *Metapenaeus* spp.
		Semi-intensive prawn culture		
India (Suseelan 1976)	3	1134 per year	3.4	*P. indicus*
Japan (Shigueno 1973, 1975)	150	2000-2500 per six months	4.000	*P. japonicus*
Korea (Bardach *et al* 1972 and Rabanal 1977)	50	No data	30	*P. orientalis*
Philippines (Blanco 1973, Bardach *et al* 1972)	166,000	250-900 per year	No data	*P. monodon* *M. ensis*
Taiwan (Chen 1973, Bardach 1972, Rabanal 1977)	42	750--1500 per year	549	*P. japonicus* *P. monodon* *P. teraoi* *P. semisulcatus* *M. ensis*
U.S.A. Marifarms Inc. Florida (Uchida 1973)	1,012	336 in 7 months	—	*P. aztecus* *P. duorarum* *P. setiferus*
Louisiana (Broom 1969)	Experi-mental	45-906 per year	—	*P. aztecus* *P. setiferus*
Gould *et al* 1973	Experi-mental	318--596 in 3 months	—	*P. aztecus*

1	2	3	4	5
Brazoria County (Parker & Holcomb 1973)	Experi-mental	339-759 in 3 months	—	*P. aztecus* *P. setiferus*
		Intensive prawn culture		
Japan (Shigueno 1973)	Experi-mental	22,000 in 6 months	—	*P. japonicus*

Constraints and problems in penaeid shrimp culture

In the tropical Indo-Pacific countries where large areas of coastal swamps are awaiting to be reclaimed for prawn culture, the major constraint is the non-availability of finances for pond construction and other expenditure connected with culture operations. Low-interest bank loans should be made available to the entrepreneurs. Once the profitability of the culture operations is demonstrated through pilot-scale operations, institutional finance will become readily available.

Lack of trained personnel to operate the farms is also a major constraint in the development of prawn farms. The technical know-how that has been developed in many countries of the world has not seeped to the level of the prawn farmer. This problem is now being tackled in countries such as Philippines and India by organising short-term training courses for prospective and actual prawn farm operators and also at the trainers level. The South East Asian Fisheries Development Centre in the Philippines is organising regular training programmes for extension workers and prawn culturists. The I.C.A.R. has established a Krishi Vigyan Kendra under the Central Marine Fisheries Research Institute at Narakkal to impart training in various aspects of prawn culture to the prawn farmers.

Pilot-scale projects to demonstrate the economic and technical viability of the prawn culture operations is also being taken up by the Central Marine Fisheries Research Institute at various centres in India.

Improvement of the existing prawn culture practices in Kerala and West Bengal should receive priority attention and efforts to extend them to other suitable areas on the east and west coasts of India should be taken up. In countries like India, where large areas of land are available for prawn culture, labour is cheap and financial resources are poor, less expensive techniques contributing to low costs of production deserve due attention. Though the yield may be comparatively low, the high price commanded by the harvested product compensates for the low yield. Sophisticated methods of intensive culture with high yields can be introduced at a later stage.

Many engineering problems connected with siting of the ponds and reduction in cost of construction of the ponds deserve urgent attention. Other priority areas of research are: (1) Production of quality prawn seed on a large scale. (2) Domestication of desirable species of penaeid prawns in the farms so that mature females are readily available for seed production. (3) Methods of preparation of the ponds to increase the natural productivity of the ponds by suitable manuring procedures. (4) Stock manipulation to increase the yield from the ponds. (5) Standardization of stocking procedures for monoculture and polyculture of prawn species and mixed culture of prawns with compatible species of fish such as mullets, milkfish and *Etroplus*. (6) Compounding of inexpensive artificial feeds to increase the growth rate of stocked prawns. (7) Improving the harvesting methods to recover the cultured crop from the ponds quantitatively. (8) Understanding the nature of shrimp diseases and evolving suitable methods to control them.

Prospects of prawn culture in India

It is estimated that India has 2.6 million ha of backwaters, lagoons and estuaries out of which 3 lakh ha can be utilized for culturing prawns. But at present only about 10,000 ha are being utilized for culturing prawns employing the traditional methods. There is thus great scope for expanding prawn culture activities in India. Even by using the extensive type of culture in the additional acerage to be brought under

prawn cultivation, the prawn production from culture operations alone could easily be increased to 100,000 tonnes annually. As the prawn industry is export oriented, the additional yield from culture operations will bring in more foreign exchange and also improve the rural economy of the country.

References

ALIKUNHI, K .A., M. BUDIONO, S. ADISUKRESNO AND S. BUSMAN. 1975. Bull. Shrimp Cul. Res. Cent., 1 (2): 47-55.

BLANCO, G. J. 1973. Coastal Aquaculture in the Indo-Pacific region, Ed. T. V. R. Pillay P. 60-67.

BARDACH, J. E., J. H. RYTHER AND W. O. MCLARNEY. 1972. Aquaculture: The farming and husbandry of freshwater and marine organisms.

CHEN, T. P. 1973. Coastal Aquaculture in the Indo-Pacific region, Ed. T. V. R. Pillay P. 68-73.

DANG, LE VAN. 1973. Coastal Aquaculture in the Indo-Pacific region, Ed. T. V. R. Pillay P. 105-108.

FISHERIES DIVISION, MALAYSIA. 1973. Coastal Aquaculture in the Indo-Pacific region, Ed. T. V. R. Pillay FAO, Rome 52-59.

GOULD R. A., D. V. ALDRICH AND C. R. MOOK. 1973. Proc. Fourth Annual Workshop, World Mariculture Society, Mexico, Jan. 23-26, 1973. pp. 195-213.

NAIR, R. V., MOHAMED K. H. AND P. BENSAM. 1975. Indian farming, 25 (6): 28-33.

PARKER, J. C. AND HOLCOMB H. W. 1973. Proc. Fourth Annual Workshop, pp. 215-234.

RABANAL, H. R. 1977. Aquaculture in South East Asia.

ROSE, C. D., HARRIS, A. H. AND B. WILSON. 1975. From Amer. Fish. Soc., 104 (2): 296-307.

SHIGUENO, K. 1975. Shrimp Culture in Japan, Tokyo, 1-153.

SRIBHIBHADH, A. 1973. Coastal Aquaculture in the Indo-Pacific region, Ed. T. V. R. Pillay P. 74-83.

SUSEELAN, C. 1976. *Bull. Dept. Mar. Sci. Univ. Cochin, VII* (3): 477-486.

UCHIDA, R. N. 1973. Coastal Aquaculture in the Indo-Pacific region, Ed. T. V. R. Pillay P. 84-104.

3

TAXONOMY AND DISTRIBUTION OF CULTIVABLE PRAWNS

by

M. M. Kunju

MORPHOLOGY

A knowledge of certain morphological characters is essential for the identification of the prawns. These characters are shown in figs 1 and 2. The main features of systematic importance are the rostrum, carapace with various spines and carinae, telson, appendages and secondary sexual characters like petasma and thelycum.

SYSTEMATICS

The more important cultivable species belong to two families of Sub-Order Natantia, Order Decapoda. They are distinguished as given below:

1. Antennules with 2 flagella; walking legs 1 to 3 chelate; pleurae of second abdominal segment overlap those of first segment only
   ---- fam. Penaeidae.

2. Antennules with 3 flagella, walking legs 1 and 2 chelate; pleurae of second abdominal segment overlap those of first and third segments
   ---- fam. Palaemonidae

Family Penaeidae

1. Rostrum serrated on both margins
   ---- Genus *Penaeus*

   Rostram serrated on dorsal margin only ---- 2

2. Exopodite present on basis of fifth leg
   ---- Genus *Parapenaeopsis*

   Exopodite absent on fifth leg
   ---- Genus *Metapenaeus*

Genus Penaeus

1. One or three teeth on the ventral margin of rostrum; body with transverse coloured bands ---- 2

   More than three teeth (4 to 6) on the ventral margin of rostrum; body without transverse coloured bands ---- 4

2. One tooth on ventral margin of rostrum ---- *P. canaliculatus*

   Three teeth on ventral margin of rostrum ---- 3

3. Adrostral groove deep, extending upto half-way along the carapace, exopodite on fifth leg present; hepatic ridge oblique ---- *P. semisulcatus*

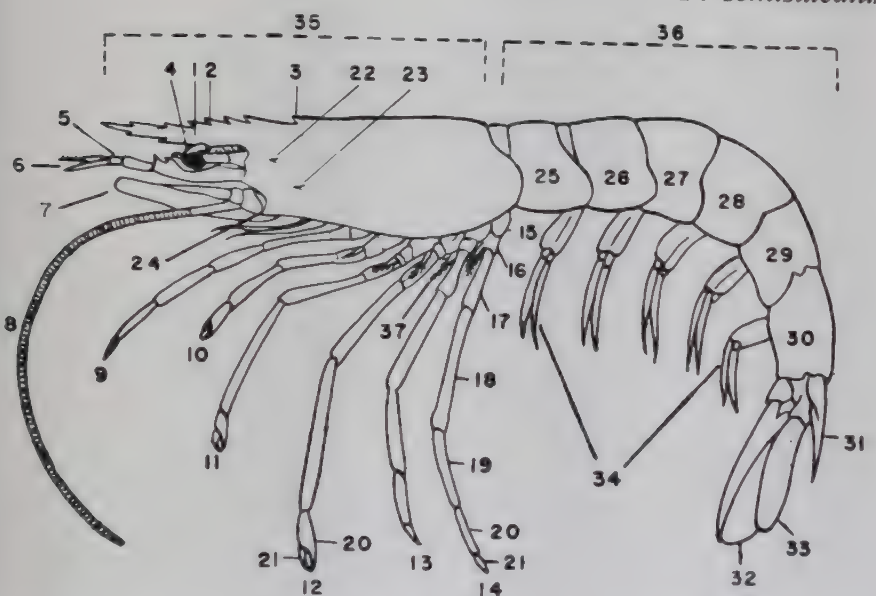

FIG. 1. Diagramatic drawing of a prawn to illustrate its taxonomic characters. 1. Rostrum 2. Rostral spines 3. Epigastric spine 4. Eye 5. Antennule 6. Antennular flagella 7. Antennal scale 8. Antennal flagellum 9. Third maxilliped 10-14. Ist to 5th pereopods 15. Coxa 16. Basis 17. Ischium 18. Merus 19. Carpus 20. Propodus 21. Dactylus 22. Post-orbital spine 23. Hepatic spine 24. Pterygostomian spine 25-30. 1st-6th abdominal somites 31. Telson 32. Exopod of the uropod 33. Endopod of the uropod 34. Pleopods 35. Carapace 36. Abdomen 37. Exopodite.

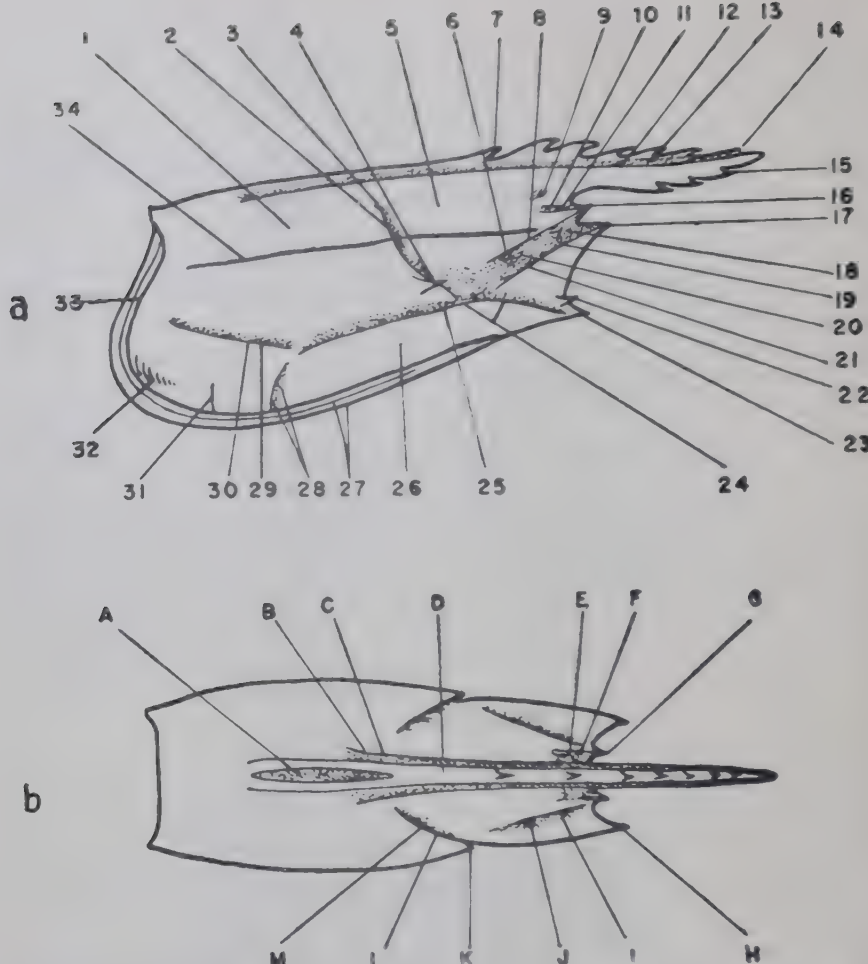

FIG. 2. a. Diagramatic representation of carapace to show features of taxonomic importance. 1. Cardiac region 2. Cervical carina 3. Cervical sulcus 4. Hepatic spine 5. Gastric region 6. Gastro-orbital carina 7. Epigastric spine 8. Orbito-antennal sulcus 9. Post-ocular sulcus 10. Gastro-frontal sulcus 11. Gastro-frontal carina 12. Adrostral carina 13. Adrostral sulcus 14. Rostral tooth 15. Ventral rostral tooth 16. Orbital or supraorbital spine 17. Antennal spine 18. Post-orbital spine 19. Antennal carina 20. Post-antennal spine 21. Orbito-antennal sulcus 22. Branchiostegal spine 23. Pterygostomian spine 24. Hepatic carina 25. Hepatic sulcus 26. Pterygostomian region 27. Marginal region 28. Inferior carina and sulcus 29. Branchio-cardiac carina 30. Branchio-cardiac sulcus 21. Transverse suture 32. Stridulating organ 33. Pterygostomian sulcus 34. Longitudinal suture.

b. A. Post-rostral median sulcus B. Adrostral sulcus C. Adrostral carina E. Gastro-frontal carina F. Gastro-frontal sulcus G. Orbital or supraorbital spine H. Antennal spine I. Gastro-orbital carina J. Orbito-antennal sulcus K. Hepatic spine L. Cervical sulcus M. Cervical carina.

Adrostral groove shallow and does not extend beyond the rostrum; exopodite on fifth leg absent; hepatic ridge longitudinal

---- *P. monodon*

4. Gastro-orbital carina occupying the posterior 2|3 distance between hepatic spine and orbital angle; rostral crest only feebly elevated, not triangular in profile

---- *P. indicus*

Gastro-orbital carina occupying the middle 1|3 distance between hepatic spine and orbital angle; rostral crest conspicuously high, forming an elevated triangular crest

---- *P. merguiensis*

Genus Parapenaeopsis

1. Hepatic carina running on to branchiostegal tooth; strong telsonic spines; dull brown in colour

---- *P. stylifera*

Hepatic carina does not reach branchiostegal tooth; telsonic spines, if present, are weak; with dark transverse bandson body

---- *P. sculptilis*

Genus Metapenaeus

1. Rostrum straight ---- 2
Rostrum curved ---- 3

2. No rostral crest; first abdominal segment carinated; rostrum extends beyond the second segment of the antennular peduncle

---- *M. monoceros*

Rostral crest present; first abdominal segment not carinated; rostrum does not extend beyond the second segment of the antennular peduncle

---- *M. brevicornis*

3. Slightly curved rostrum without noticeable crest; last pair of thoracic legs surpass the antennal scale ---- *M. affinis*

Rostral curvature pronounced with a crest; last pair of thoracic legs falls short of middle of antennal scale ---- *M. dobsoni*

Family Palaemonidae

Only one genus.

Genus Macrobrachium

1. Rostrum with an elevated rostral crest; reaching beyond antennular peduncle ---- 2
   Rostrum without an elevated rostral crest, and not reaching beyond tip of antennular peduncle ---- 3
2. Rostrum as long as or longer than carapace ---- *M. rosenbergii*

   Rostrum shorter than carapace ---- *M. malcolmsonii*

3. Dorsal margin of rostrum slightly convex, with 12 or more teeth ---- *M. rude*

   Dorsal margin of rostrum straight, with less than 12 teeth ---- *M. idae*

DISTRIBUTION

Most of the species are distributed throughout the coasts of India, abundance in certain areas varying with species.

P. canaliculatus. Found in both the coasts. More common in creeks.

P. semisulcatus. Found in both east and west coasts; support commercial fisheries in the Sunderbans and along the east coast.

P. monodon. More common on the east coast, especially in Bengal and Orissa where it contributes to a fishery. Small numbers found all along the Indian coast.

P. indicus. Found all along the coasts, more abundant in the southwest and southeast coasts; form a considerable fishery in the estuaries and backwaters.

P. merguiensis. Though found throughout the Indian coast, support commercial fisheries only in Goa, Karwar, Vizagapatnam and Puri.

Parapenaeopsis stylifera. Found all along the coast. Commercially exploited in the west coast. Suitable only for marine culture, since at no stage the prawn enters brackishwater areas.

P. sculptilis. Though found all along, more common in Bombay and estuaries of W. Bengal.

Metapenaeus monoceros. Throughout the Indian coast; juveniles abound in estuaries. Mature large prawns are found only in offshore areas.

M. brevicornis. Found only in northern regions of both the coasts, where the juveniles occur in estuarine areas and adults in the inshore waters.

M. affinis. A species of commercial importance all along the Indian coasts.

M. dobsoni. One of the most abundant species particularly along the Kerala coast. Adults in the inshore areas and juveniles frequent estuaries and backwaters.

Macrobrachium rosenbergii. Common in most of the lakes and estuaries.

M. malcolmsonii. Found more commonly in the rivers of peninsular India, and in the rivers and estuaries of W. Bengal.

M. rude. Common in Kerala, deltaic Bengal, Orissa and Andhra.

M. idae. Distribution almost same as *M. rude;* but more common in the east coast.

4

FEATURES OF PRAWNS WHICH CONTRIBUTE TO THEIR SUITABILITY FOR CULTURE

by

N. Surendranatha Kurup

Selection of suitable species for culture forms an important aspect of pre-farming activities. Success or failure of a culture enterprise largely depends upon the demand of the commodity and the economics of culture operation, which in turn are based on certain features of the species selected for culture. Thus, all the species of prawns and shrimps that occur in our waters are not suitable for culture; but only a few of them that possess the favourable features are suitable for this purpose. These characteristics of prawns are discussed in this paper.

Features of prawns which favour their selection for culture can be broadly categorised under two headings namely the biological and economical. Among the biological features the most important aspects are the distribution of species; reproductive characteristics; larval development; growth rate and hardiness of the animal.

Distribution of the species

Most of the culture operations are carried out at present in the coastal inshore regions or in the estuaries or backwaters and hence the species that occur around these zones of operations have greater advantages than those species that are distributed far away from this area. Most of the prawns which are cultured at present are littoral in distribution having their bathymetrical distribution confined to the inner half of the continental shelf. Of the littoral species of prawns, those having differential distribution are more suitable for culture than those restricted to a particular environment. Most of the penaeid prawns of our coast have such differential distribution,

their eggs and early larvae occuring in the sea and the post-larval and juvenile stages in the estuaries. It may be noted that the traditional culture practice prevalent in Southeast Asian countries, and in India is mostly based on the juvenile phase of these species that is being spent in brackishwater environments.

Reproductive characteristics

Availability of spawners close to the area of culture operation, their occurrence during greater part of the year, capacity to breed more than once and to produce large number of eggs and spawning under captivity are the salient reproductive features of prawns which contribute to their suitability for culture. Most of the penaeid prawns of our coast breed in the inshore grounds. The larger species such as *Penaeus indicus* and *Metapenaeus monoceros* breed in slightly deeper waters while the smaller species like *Metapenaeus dobsoni* and *Parapenaeopsis stylifera* do the same in shallow waters. These prawns breed readily under captivity if favourable conditions are provided. All of them have protracted breeding habits and are capable of producing larger number of eggs. Rao (1968) has estimated the fecundity of *P. indicus* as 68,000 eggs in a female measuring 140 mm total length, and 731,000 eggs in female of 200 mm size. In *P. monodon*, the number of eggs produced varies from 3 to 7 lakhs. George (1969) had estimated fecundity in *M. dobsoni* ranging from 34,500 to 1.59,000 eggs and in *M. affinis* between 88,000 to 3,63,000. In almost all these cases an average of 50% hatch out to nauplii. Another important characteristic of penaeid prawns is the ability of females to produce viable eggs without the presence of males. The females carry sperms in the thelycum, which is liberated into the water at the time of ovulation. Although the penaeid prawns could produce large number of eggs, it is natural to expect a higher rate of mortality as the eggs are liberated into the open sea. But, in the case of palaemonid prawns which carry the fertilised eggs in the pleopods and undergo part of the development there, the number of eggs produced is comparatively less. The mortality also would be at a lesser rate in the early stages.

Larval development

Duration of larval development in penaeid prawns is relatively short; all the 13-15 stages in the larval development in the early life history are being completed in 12-17 days. In the case of palaemonid prawns, however, the life cycle is fairly long and takes about 40-50 days to complete the metamorphosis.

Growth rate

Selection of a suitable species largely depends upon its growth rate. The fast growing varieties yielding short-term harvests are the most suitable species for intensive prawn farming. Mohamed and Rao (1971) have worked out the estuarine phase of cultivable species of prawns. According to them the minimum period of stay in the backwaters and the size when they leave this ecosystem are estimated to be 5 months and 50 mm for *M. dobsoni;* 4 months and 40 mm for *M. affinis;* 10 months and 85 mm for *M. monoceros* and 6 months and 80 mm for *P. indicus*. Similarly the growth of *P. monodon* has been worked out by Subramanyam (1972) as 160-170 mm in about 6 months in natural brackishwater environments. The same species is believed to attain a size of about 250 mm in one year in prawn ponds of Philippines. The growth rate of *P. indicus* is considered to be very fast compared to other common forms. Jhingran and Natarajan (1969) have estimated growth rate as high as 36 mm month for this species in Chilka Lake. Still faster growth has been observed in allied species from other regions.

Feeding habits

The habit of feeding on a wide range of items is another factor contributing to their suitability for culture. A purely herbivorous or carnivorous feeding habit is not seen in any of the species. The food preference varies considerably at different stages of the life history of a prawn. The larvae feed on planktonic items. The juveniles, and adult prawns, feed mostly on organic detritus and a variety of animals and

plant materials available at the bottom. A wide range of feeding habits in different habitats effect a faster growth rate and higher survival rate for prawn larvae and make culture a profitable practice.

Hardiness of the animal

The hardiness of prawns make them suitable for cultivation. Since the various stages in the life history of prawns are distributed in widely fluctuating habitats, they show different tolerences and preference to environmental factors. Among these, salinity and temperature are considered to be the most important factors. These factors play important roles and the maturation of ovaries and the breeding of penaeid prawns. Experiments conducted at the CMFRI have indicated that most of the penaeid prawns have wide adaptability to varying salinity and temperature conditions in the early stages. The ability of larvae and juveniles to adjust to changes in salinity and temperature and the naturally evolved life history which is preadapted to different ecosystems make most of the species ideally suitable for cultivation under controlled conditions.

Economical factors

Recently, the greater demand for prawn products in internal and external markets has made prawn farming more attractive. The frozen prawns are exported to countries like America, Japan and France. The freezing industry has also become wide spread all over the country and the demand for large-sized prawns by industrialists has increased considerably. The competitive demand for prawns from all over the world is so much that new price levels are being reached every year for this commodity. At present the price for headless prawns has crossed Rs. 100 per kg in America while it is ranging between Rs. 72-80 in the Indian markets. In the context of greater demand for larger prawns in the export trade, species that grow very rapidly and attain bigger size in the shortest period have to be selected for profitable commercial culture.

References

George, M. J. 1969. Prawn Fisheries of India: Genus *Metapenaeus* Wood-Mason & Alcock 1891. *Bull. cent. mar. Fish. Res. Inst.*, 14: 77-125.

Jhingran, V. G. and A. V. Natarajan. 1969. A study of the fisheries and fish populations of the Chilka Lake during the period 1957-1965. *J. Inland Fish. Soc. India*, 1 (1): 49-126.

Mohamed, K. H. and P. V. Rao. 1971. Estuarine phase in the life history of the commercial prawns of the west coast of India. *J. mar. biol. Ass. India,* 13 (2): 149-161.

Rao, P. V. 1968. Maturation and spawning of the penaeid prawns of the South-West Coast of India. *FAO Fish. Rep.*, 57 (2): 285-302.

Subramanyam, M. 1972. Experimental Studies on Growth in *Penaeus monodon* Fabricius. *Seminar on Mariculture and Mechanised fishing, Proceedings,* Madras, 28 & 29 November 1972, 70-73.

5

FOOD AND FEEDING OF PRAWNS

by

M. M. Thomas

The study of food, feeding and assimilation is of fundamental importance for the proper understanding of the growth rate, population concentrations, gonadial maturation and other metabolic activities. Although prawns which inhabit the shallow areas form the bulk of the crustacean resources of the world very little work has been done in many countries on the food, feeding and assimilation in these animals. Detailed studies have been made in India on the 'stomach' contents of *Penaeus indicus* (Gopalakrishnan 1952) food and feeding of *Penaeus monodon* from Korapuzha Estuary (Thomas 1973), *Penaeus semisulcatus* from the Gulf of Mannar and

Palk Bay (Thomas 1972) and the food and feeding of some penaeid prawns from Cochin area (Kuttyamma 1974). Panikkar (1952), Panikkar and Menon (1956), Kunju (1967) and George (1959) have mentioned the food of some of the penaeid prawns while studying their biology. In USA, Williams (1955) and Eldred *et al* (1961) have studied this aspect in the North American species, *P. setiferus, P. aztecus* and *P. duorarum* while Hall (1962) and Dall (1968) have investigated the food and feeding of Malaysian and Australian species, respectively.

Food and feeding

Considerable differences have been noticed in the food preferences of the various larval stages, juvenile and adult prawns. The larvae in the nauplius stage do not feed at all, as they have food reserve in the form of yolk. But protozoea larvae feed voraciously on phytoplankton such as *Tetraselmis* spp., *Synecocystes* spp., *Thalassiosira* spp., *Skeletonema costatum,* etc. It has been observed that the Indian species viz., *Metapenaeus affinis, M. dobsoni* and *Parapenaeopsis stylifera* thrive well on cultures of the diatom, *Thalassiosira* spp., registering very high (90% in *M. affinis*) survival rates (Thomas *et al* 1975, 1976a and 1976b). In the mysis stages they feed well on brine shrimp nauplius and yeast granules.

Adult prawns are reported to feed on a variety of animals and plant material available in the area where they live. They feed on crustaceans, polychaetes, molluscs, radiolarians, forameniferans, pisces, diatoms, algae, etc. along with considerable quantities of organic detritus from the bottom of the sea or backwater. It has been observed that *P. semisulcatus* were actively feeding in the night and that the quantity of food items varied considerably depending on the abundance of these items during the seasons. It is evident that they are, in general, not selective feeders.

There has been individual variations among the species reported by various workers from different localities.

P. indicus has been reported to feed on plant material in the younger stages while the older ones prefer a predominently

crustacean diet. Algal filaments also form part of the food of this species. *P. monodon* feed on molluscs, crustaceans, polychaetes and fish remains. *P. semisulcatus* consume large quantities of animal matter viz., polychaetes, crustaceans, molluscs, radiolarians, forameniferans and fishes as well as diatoms and algal filaments. *M. dobsoni* feed mainly on crustaceans, algal filaments, seaweeds and diatoms such as *Fragilaria, Coscinodiscus, Pleurosigma, Biddulphia* etc. *M. monoceros* eat crustaceans including copepods, ostracods, amphipods and decapod larvae in addition to plant materials like seaweeds and algae.

Digestive system

The oesophagus is a short tube continuing vertically into anterior chamber of the proventriculus ('stomach') which extends backwards as the gastric mill. The groves on the floor of the anterior chamber serves for the passage of the digestive secretions from the digestive gland which get mixed up with the food ingested. The posterior chamber of proventriculus is partly embedded in the digestive gland and is divided into a dorsal channel which leads directly into a long simple midgut and a ventral 'filter press' which allows only fine particles to pass into the digestive gland.

The digestive gland is compact in shape, forming about 3-4% of the total weight of prawn. There are two openings from the ventral 'filter press' directly into the simple tubules which constitute the gland. The tubule walls are formed of a single layer of epithelial cells distinguished as the 'secretary cells' and 'Storage cells', the latter containing polysacchorides (Dall 1965). Proteinases which are enzymes in the digestive juice are reported from *P. orientalis*. The rapid postmortem autolysis of the digestive gland found to occur in prawns is due to these enzymes. Amylase equivalent to 40 units per gram (wet weight) was also found in the digestive gland. It is probable that Lipases may also be present as the fats are emulsified by the digestive glands.

By the time the food reaches the digestive gland, digestion is well under way and is completed in the proximal half of the digestive gland tubules. The larger indigestible

particles are passed backwards through the dorsal part of the posterior proventriculus into the midgut from where they are expelled as faecal matter through the rectum when the midgut is full. The anterior and posterior diverticula of the midgut appear to be responsible for the osmotic and ionic regulations (Dall 1967) and have no digestive function.

Rate of digestion

When a starved prawn is fed with enough soft food anterior chamber of proventriculus gets filled up to capacity within two minutes. Since the rates of ingestion and digestion are more or less equal, the relatively smalll size of the 'stomach' is not a major disadvantage.

Defecation in starved animals start an hour after feeding reaching peak in 4-6 hours after and if the feeding is confined to beginning of the experiment, ceases by eight hours, although some residue may remain in the gut up to twenty hours. It seems likely that assimilation can be very rapid, especially when the food is in very fine form. This conforms with the general indications that penaeids may have high metabolic rate when they are active and low food reserves (Dall 1965).

References

Dall, W. 1965. Studies on the physiology of a shrimp. *Metapenaeus* sp., (Crustacea: Decapods: Penaeidae). 4. Carbohydrate Metabolism. *Aust. J. mar. Freshwat. Res.,* 16: 163-180.

———— 1968. Food and feeding of some Australian penaeid shrimp. *FAO Fish. Rep.,* 57 (2): 251-258.

Eldred, B. *et al* 1965. Biological observations on the commercial shrimp, *Penaeus duorarum* Burkenroad in Florida waters. *Prof. Pap. ser. mar. Lab. Fla.,* 3: 1-139.

Gopalakrishnan, V. 1952. Food and feeding habits of *Penaeus indicus*. *J. Madras Univ.,* (B): 22 (1): 69-75.

Hall, D. N. F. 1962. Observations on the taxonomy of some Indo-West-Pacific Penaeidae (Crustacea: Decapoda). *Fish. Publ. Colonial off.,* 17: 1-229.

KUTTYAMMA, V. J. 1974. Observations on the food and feeding of some penaeid prawns of Cochin area. *J. mar. biol. Ass. India*, 15 (1): 189-194.

THOMAS, M. M. 1973. Food and feeding habits of *Penaeus monodon* Fabricus from Korapuzha Estuary. *Indian J. Fish.*, 19: 202-204.

——— 1972. Studies on Indian Decapods. Ph.D. Thesis, Kerala University.

———, K. V. GEORGE AND M. KATHIRVEL. 1975. On the spawning and early development of the marine prawn. *Parapenaeus opsis stylifera* (H. Milne Edwards) in the laboratory. *Indian J. Fish.*, 21 (1) 266-271.

———, M. KATHIRVEL AND N. N. PILLAI. 1976. Spawning and rearing of the penaeid prawn, *Metapenaeus affinis* (H. Milue Edwards) in the laboratory. *Indian J. Fish.*, 21 (2): 543-556.

——— 1976b. Observations on the spawning and rearing of *Metapenaeus dobsoni* under laboratory conditions. *Indian J. Fish.*, 21 (2): 575-579.

WILLIAMS, A. B. 1955. A contribution to the life histories of Commercial shrimps (Penaeidae) in North Carolina. *Bull. mar. Sci. Gulf Caribb.*, 5 (2): 116-146.

6

GROWTH IN PRAWNS

by

M. M. Kunju

A knowledge of the pattern and rate of growth of the individuals of each species of prawn is essential for a clear understanding of their general biology. Growth is manifested as an increase in size of the prawn, and as such is best measured in terms of its volume or weight. But, it is usually gauged from observation of its linear dimension, i.e., total length. It has been mathematically proved that there is a fairly

constant relationship between total length and weight of the individuals of the species. Therefore, when a knowledge of the growth in volume or weight is required, it is usually calculated from length-weight relationship.

Three general methods of determining the growth of prawns are available, namely:—

1. Comparison of length-frequency distribution.

2. Rearing individuals in captivity.

3. Tagging.

Since the first method is the predominant one to be followed let us keep it aside for detailed study in a later section.

Rearing individual prawn is an experimental method where a prawn of known length is kept in captivity and periodically taken out and measured to record the growth in the intervening period. This method provides valuable information on the rates of growth of individuals under varying environmental conditions such as temperature, food supply, etc.

The most direct and positive way of determining the growth is by liberation of marked or tagged prawns of known lengths. Marking is done either by stains (by injection, feeding or immersion), or by tagging (internal or external tags). When these prawns are subsequently recaptured there can be no doubt as to the growth of the specimens, provided accurate records have been maintained.

The above two methods are not suitable for determining the average rate of growth of the individuals in the population.

LENGTH-FREQUENCY METHOD

The length-frequency-distribution method has been used to estimate age and growth since very early times. The length measurements may be obtained from samples taken from the population at intervals throughout the life of each brood or age-group.

The principles underlying this method may be summarised as follows:—

1. The lengths of the individuals of each age-group or brood in a population are approximately "normally" distributed, ideally in population with restricted spawning seasons.

2. Growth is such that the modes of the length distribution of successive age-groups or broods in a sample taken from the population are separated along the length axis and may be readily distinguished.

3. When the length-frequency distribution of a sample containing a number of age groups or broods is drawn, a polymodal curve is obtained, the separate modes of which represent the approximate mean size of the constituent age groups.

The development of appropriate statistical techniques for the dissection of polymodal frequency curves into their normal components has greatly increased its usefulness. The use of probability paper is one such method.

Though these are ideal postulates, difficulties may arise in the interpretation of the modes as shown below:—

1. The length-frequency distribution of each age-group does not always approach normality which makes separation of modes difficult and sometimes impossible. Non-normality may result from a number of causes, amongst the most important of which are prolongation of the spawning period (which most of our prawns have), and selection by fishing gear. However, length-frequency distribution based on good and large random samples of the population collected over a long period often show fairly reliable modal progressions.

2. Difficulty may be experienced in assigning successive modes to specific age-groups unless the age of first capture by the sampling gear is known.

3. The growth increment from year to year may be insufficient for distinct modes to be recognisable in the length-frequency distribution, particularly at the greater lengths.

Length studies of exploited prawn species have mostly been made on data obtained by the length-frequency measurements taken from successive samples from the commercial landings. These data cannot be used to measure the growth history of particular individuals, but when collected properly they permit the evaluation of the average growth history of successive broods. The accuracy with which the average growth condition may be gauged by this means is largely dependent upon the reliability of the gear with which the prawns are caught.

LENGTH-WEIGHT RELATIONSHIP

Weight may be considered as a function of length. This relationship of the length and weight follows approximately the cube law relationship expressed by the formula:

$$K = W/L^3$$

where W = Weight and L = Length

If form and specific gravity were constant throughout life, the relationship could be used to describe the general length-weight relationship in populations of prawns and thus serve as the basis for the calculation of unknown weights of prawns of known length, or determine the lengths of prawns of known weight. Unfortunately, the prawn is continuously prone to change its bodily proportions during life so that the simple cube law expression does not hold good throughout the life history and growth of the prawn. Therefore, a more satisfactory formula for the expression of the relationship is:

$$W = CL^n$$

where W = Weight, L = length, C and n are constants or expressed logarithmetically $\log W = \log c + n \log L$

The values of the constants c and n may be determined by fitting a straight line to the logarithm of L and W, or by computing them from the following normal equation

$$\log c = \frac{\Sigma \log W. \ \Sigma (\log L)^2 - \Sigma \log L \ (\Sigma \log L \log W)}{N \ \Sigma (\log L)^2 \quad - (\Sigma \log L)^2}$$

and

$$n = \frac{\Sigma\,(\log W \quad - \quad N \log c}{\Sigma \log L}$$

GROWTH RATES IN DIFFERENT NATURAL ENVIRONS AT DIFFERENT LIFE STAGES

Growth rate varies in different species, and at different phases of life and under different physical conditions like temperature, salinity, etc. Almost all the species show faster growth when young and below one year in age. The growth decreases as the prawn grows older. Growth of some important cultivable species is given below:—

P. indicus

The male and female attain lengths of 128 and 143 mm at the end of the first year, and 163 and 173 mm at the end of the second year respectively in the open sea. Prawns growing beyond 195 mm are rare and they are presumed to be over 3 years old. Growth rate is about 15 and 20 mm per month in male and female respectively towards the end of the first year. Growth of juveniles of 30 to 100 mm is much faster when they are in the estuaries and backwaters. Greatest size recorded is 230 mm.

M. dobsoni

Life span is 2 to 3 years and greatest size attained is 128 mm for females and 118 mm for males. Growth rate is much faster in the backwaters than in the sea, where they grow to 60 to 80 mm in 7 or 8 months. In the open sea the growth rates are 20 and 25 mm per month in male and female respectively during the first 6 months. They attain lengths of 70 and 75 to 80 mm, 90 to 95 and 100 to 105 mm, and 110 and 120 mm in male and female respectively at the end of first, second and third year of life.

M. monoceros

Life span is 3 years and maximum size attained is 180 mm. They grow to 100 to 110, 131 to 135 and 156 to 160 mm at the end of first, second and third year respectively.

M. affinis

Life span is 2 to 3 years and greatest size is 165 to 170 mm. In the trawl fishery the growth rate is 20 and 25 mm| month in male and female respectively. Length of 105 and 135 mm, 115 and 155 mm, and 155 and 175 in male and female respectively are attained at the end of first, second and third year.

M. brevicornis

Life span is 3 years and maximum size attained is 127 mm. Lengths of 46 and 47 mm and 81 and 89 mm in male and female are attained respectively at the end of the first and second year. After the postlarval phase it grows at 3 mm| month. Growth rate is faster in summer, less in rainy season and lowest in winter.

Macrobrachium rosenbergii

The growth of the prawn in the Hooghly estuary in W. Bengal is as follows:—

	Male	*Female*
I year	114 mm	83 mm
II "	142 mm	127 mm
III "	226 mm	158 mm
IV "	261 mm	221 mm

In the Kerala backwaters growth is much faster, where females attain 200 mm in one year and males slightly larger. From June to October males grow at 20 mm month. In the other months growth rate is slower.

M. malcolmsonii

Maximum size attained is 230 mm in male and 150 mm in female. Life span is 3 to 3½ years in female and 4 to 4½ years in male. Growth of the species in the Godavary river is as follows:—

	Male (mm)	*Female (mm)*
I year	80	75
II year	143	114
III year	193	149

The growth is much slower in the Hooghly estuary.

GROWTH RATES IN CULTURE FIELDS

Wherever it has been possible to conduct culture techniques on scientific basis, the growth of prawn has been spectacular compared to the growth recorded from natural conditions. Typical example is provided by the instance of *Penaeus monodon* extensively cultured in Philippines. Its growth in the culture ponds is tabulated below:—

Age of prawn in months	*Length in mm*	*Weight in g*
2	79	4.34
6	142	22.38
9	178	57.39
12	230	95.18

Properly fed and under proper temperature and other conditions the young one of size 12 to 15 mm could be grown to 26 to 32 mm in 26 days. The greatest length recorded for the species is 337 mm.

In the Malaysian prawn ponds *P. indicus* has been found to grow at the fast rate of 0.102 mm carapace length per day.

In Japan where prawn culture is commercially successful, 20- to 25-day old post-larvae of *P. japonicus* weighing 0.020 g has been reared to marketable size of 20 g in 5 months.

M. rosenbergii cultured in Penang (Malaysia) has been found to grow rapidly. The further growth of 60 day old young prawns is tabulated below:—

Period in months	*Weight in g*	*Length in mm*
1	10	76
3	25	140
6	125	225

Growth in the female practically ceases when it reaches 120 g in weight, whereas the male continues to grow till it attains 200 g in weight. The juveniles which are metamorphosed from the last larval stage, settle down to become crawlers. They grow rapidly moulting every 5 to 10 days, attaining a length of 50 mm in 2 months.

FACTORS INFLUENCING GROWTH

Salinity, temperature, oxygen, food supply, disease and parasitism and physiological stress are the main factors influencing growth. Growth of the prawn would be maximum in the particular phase of life, where these conditions are available to the optimum limit, which vary with each cultivable species and under different life stages.

1. *Salinity*: Salinity is a limiting factor in the growth of most species both directly and indirectly. All the cultivable species tolerate a range in salinity, which varies from species to species and at different life stages. Most penaeid species grow faster at lowered salinities when they are in their juvenile phase, preferring an estuarine habitat. Before attaining maturity they migrate to areas of higher salinities in the open sea.

2. *Temperature*: It plays an important role in the growth of prawns. As digestion is likely to proceed very slow at low temperatures, the growth rate may also slow down.

3. *Oxygen*: Unless the maximum oxygen requirement is met growth may get retarded. In extreme cases where pollu-

tion occurs, depletion of oxygen causes total mortality. Aeration of the culture ponds is one of the main factors for successful prawn culture.

4. *Food supply*: The amount and quality of the food required at various life stages have a direct relationship with the growth of the prawn.

5. *Disease and parasitism*: A certain percentage of most prawns get infected by bopyrid parasites. These parasites are found to arrest the growth of the host prawn.

6. *Physiological stress*: When the prawn undergoes gonadial maturation or incubation of the eggs moulting and growth does not take place.

Certain other factors like density of the population and consequent availability of space for individuals, competition for the same type of food by different species or different animal forms etc may also have a direct bearing on the growth of prawns.

The life of a prawn involves periodic shedding of the old confining exoskeleton and a subsequent enlargement of the newly disclosed integument. This process is called "moulting". It is a highly complex and profound physiological event in the life of the crustacean. Visible increment in size takes place at this time. The periodicity of moulting varies according to different conditions like light, temperature, food supply, etc. Frequency of moulting depends on the age of the individual and the amount and quantity of food taken. Young specimens moult more frequently than old ones. In *M. rosenbergii* moulting takes place at irregular intervals, roughly one moult to every 10 mm of growth, males moulting 6 times and females 5 times in a year in the case of juveniles. Individuals taking ample amounts of good quality food moult sooner than those taking less or poorer food. Starvation usually inhibits moulting, whereas feeding promotes it. The prawn does not moult while undergoing gonadal maturation or incubating the eggs (in the case of pelaemonids).

A little while after the exuvia is discarded, the prawn undergoes tissue growth which lasts till the new integument

hardens. Growth and size increase actually take place at this time. Thus, tissue growth in the prawn is limited to a brief period during the intermoult cycle, that is, growth is not an uninterrupted process as in most other animals.

All the larval and postlarval stages metamorphose from one to the next or from one substage to the next substage within the same stage by the process of moulting.

7

MATURATION AND SPAWNING OF CULTIVABLE MARINE PENAEID PRAWNS

by

P. Vedavyasa Rao

An understanding of the reproductive biology of species selected for culture is an essential prerequisite for their successful farming or culture. The subject assumes further importance in the context of intensive culture involving establishment of hatcheries for selective breeding under controlled conditions and large-scale production of seed of desired species. Salient features of the reproductive activities of the marine penaeid prawns, particularly of Indian penaeids which are important from the point of view of culture, are briefly summarised in this background paper.

Review of literature

Among the early works, the significant contributions to the knowledge of reproduction of penaeid prawns were those by Heldt (1939) on Mediterranean penaeids, Hudinaga (1942) on *Penaeus japonicus* and King (1948) on *P. setiferus*. These works were later followed by the noteworthy contributions by Heegaard (1953), Linder and Anderson

(1956), Cummings (1961), Hudinaga and Miyamura (1962), Renfro and Brusher (1964) and Fujinaga (1969). Important recent works on the subject are by Villaluz *et al* (1972) and Alikunhi *et al* (1975) on *P. monodon;* Arnstein and Beard (1975) on *P. orientalis* and the investigations carried out by the 'Prawn Maturation Team' of the Aquaculture Department of the South-East Asian Fisheries Development Centre, Philippines.

The breeding habits of the Indian Penaeid prawns have been studied by Menon (1952, 1953), Shaikmahmud and Tembe (1960, 1961), Rajyalakshmi (1961), George (1962), Subrahmanyam (1963), Rao (1968), Kunju (1968) and Silas and Muthu (1977). Besides these, most of the papers dealing with the biology of the individual species contain certain information on the spawning habits of the concerned prawn.

Sexes and sexual difference

Penaeid prawns are generally heterosexual. The female prawn is usually larger than the male. In the male, the endopodites of the first pair of pleopods are modified to form a copulatory organ, the petasma or andricum. The second pleopod also shows an accessory structure, the appendix masculina. In the female, the most striking character is the presence of a ventral thoracic structure, the thelycum, situated between the last three pairs of thoracic legs. In addition to the above mentioned differences, is the location of the opening of the genital ducts. In the female, these are situated on the bases of the coxae of the third pair of pereopods, while in the male they are on the last pair.

Reproductive organs

Female: Mature ovary of penaeid prawn is a paired organ, situated dorsally, extending from the base of the rostrum to the last abdominal segment. It is bilaterally symmetrical and partly fused. Each half of the ovary consists of three lobes. The anterior lobe is slender and runs along the anterior portion of the oesophagus and gastric mill. The middle lobe has

6 or 7 finger-like lateral lobules which entirely fill the area between the anterior region and posterior border of the carapace. The thin oviducts start from the tips of the penultimate lobules of the middle lobe on either side and run downward to the external gonopore on the 3rd pereopods. The posterior lobe extends the length of the abdomen. The two halves of the ovary are united by two commissures, one at the base of the anterior lobes and the other at the tip of the posterior lobes in the sixth abdominal segment. Thelycum is the modified sternal plates of the 4th and 5th thoracic segments and consists of an anterior plate, a pair of lateral plates and a posterior plate. The structure of the thelycum varies in different species.

Male: The male reproductive system consists of a pair of testes, vas efferens, vas deferens, terminal ampoule and a petasma. The testes lie on the dorsal surface of hepatopancreas, ventral to the heart. Each half of the testis consists of several lobes extending over the surface of hepatopancreas. The vas efferens arises from the testes lobes and join into the proximal part of the vas deferens which is a thin delicate tube running downwards and backwards. The distal part of the vas deferens is thicker and has wider lumen. On the coxa of the last pair of thoracic legs the vas deferens gets dilated and ends in a distal terminal ampoule. The ampoule is sac-like and primarily a glandular structure with a thick muscular coat and contains spermatophores and a white thicky fluid.

Petasma is the modified endopods of the first pleopods. Its structure and shape vary from species to species.

Spermatozoa of penaeid prawns are minute, usually globular or ovoid in shape with a very short tail. In *Parapenaeopsis stylifera* they are elongated and cylindrical.

Maturity stages

Female: Based on the external changes in colour, size, texture and microscopical examination of the ovary, five maturity stages have been recognised in the maturation of the

ovary. These stages may be distinguished on the following points.

1. *Immature stage*: The ovaries of immature prawns are thin, translucent, unpigmented and confined to the abdomen. They contain oocytes and small spherical ova with clear cytoplasm and conspicuous nuclei.

2. *Early maturing stage*: The ovary is increasing in size and the anterior and middle lobes are developing. The dorsal surface is light yellow to yellowish green. Opaque yolk granules are formed in the cytoplasm and partly obscure the nuclei. The developing ova are clearly larger than the immature stock.

3. *Late maturing stage*: The ovary is light green and is visible through exoskeleton. The anterior and middle lobes are fully developed. The maturing ova are opaque due to the accumulation of yolk.

4. *Mature stage*: The ovary is dark green and clearly visible through exoskeleton. The ova are larger than in the preceeding stage and the peripheral region becomes transparent.

5. *Spent-recovering*: It is probable that after the extrusion of eggs, the gonad reverts almost immediately to the immature condition. This stage is, therefore, distinguishable from that found in the immature virgin females only from the size of the prawn.

Male: Five maturity stages are distinguished.

Stage I: Testis lobes are not developed. Generative portion is present in the tubular portion up to vas deferens. Spermatozoa are not formed.

Stage II: Testis lobes are fairly developed. Generative tissue is very prominent in the tubular portion.

Stage III: Testis lobes are well developed. The two components of the tubular portion are well represented. Spermatozoa present in the lumen of the follicles, tubular portion and in the terminal ampoules.

Stage IV: Testis lobes are well developed. Spermatozoa present in the terminal ampoules. This is the fully mature stage.

Stage V: Testis lobes contain only spermatozoa but not the other stages of spermatogenesis.

Size at first sexual maturity

The size at first sexual maturity of males on the basis of fusion of two halves of petasmal endopodites is found to be 102 mm in *P. indicus,* 74 mm in *M. monoceros,* 71.6 mm in *M. affinis,* 53.6 mm in *M. dobsoni* and 59 mm in *P. stylifera*. The size at first sexual maturity of females of different species of penaeid prawns is given in Table 1.

Spawning season

In the population, most of the commercial penaeid prawns show protracted breeding season often extending throughout the year. However, peak spawning season is found to vary from species to species, from place to place (Table 1) and from year to year. Usually most of the species show two peaks coinciding with the onset of the southwest monsoon and northeast monsoon.

Spawning frequency

Spawning more than once in a season has been observed in a number of penaeid prawns. The individuals of *P. indicus, M. dobsoni, M. affinis* and *P. stylifera* are found to breed five or more times during their life span after attaining the first sexual maturity. After each spawning, the individual prawns again attain maturity within about 2 months.

Spawning ground

All the commercial penaeid prawns of the country breed in the sea in relatively deeper waters of the inshore ground (deeper in relation to the area of normal existence of adult

TABLE 1. *Size at first sexual maturity of female, fecundity and peak spawning season of different species of penaeid prawns.*

Species	Size at first sexual maturity of female (mm)	Fecundity Minimum	Fecundity Maximum	Peak spawning season	
P. indicus	130.2	68,000 at 140 mm	731,000 at 200 mm	Oct-Nov May-June	at Cochin
P. semisulcatus	23 carapace length	67,900 at 29 mm c.l.	660,900 at 45 mm c.l.	June-Sept Jan-Feb	at Mandapam Camp
M. dobsoni	64.1	34,000 at 70 mm	160,000 at 120 mm	Apr-Aug Oct-Dec	at Cochin
M. monoceros	—	—	—	Jul-Aug Nov-Dec	
M. affinis	88.6	88,000 at 95 mm	363,000 at 160 mm	Oct-Dec	at Cochin
				Jan-Mar	at Calicut
				Mar, Apr, Nov, Dec.	at Goa
				Oct, Apr, June	at Bombay
M. brevicornis	100			Mar-Apr	at Kandla
M. kutchensis	—	—	—	Feb-Sept	at Kandla
P. stylifera	63.2	39,500 at 70 mm	236,000 at 120 mm	Dec-May	at Bombay
				Nov-Dec	at Madras
				Nov-July & Apr.	at Cochin
				Oct-Dec	at Ambalapuzha
P. sculptilis	75.0	—	—	Dec-May	at Hooghly
P. hardwickii	—	—	—	Oct-July	at Bombay

prawns). *M. dobsoni* and *P. stylifera* breed within 25-metre depth region, while the spawning grounds of the larger species such as *M. monoceros* and *P. indicus* are found to extend to still deeper waters up to 50-60m depth zone. *M. brevicornis* in the Bombay region moves to deeper waters for spawning whereas in Hooghly, it is found that the mature females move from the upper to lower reaches of the estuary for spawning. *M. affinis, P. stylifera* and *P. maxillipedo* prefer areas of soft mud, rich plankton and shallow coastal waters for mating and spawning.

Fecundity

Penaeid prawns have high fecundity. The number of eggs produced by female prawn varies from species to species and with the size of the prawn. Fecundity of different species of penaeid prawns is given in Table 1.

Spawning behaviour

The mating and spawning behaviour described here are based mainly on the observations of Hudinaga (1942) on *P. japonicus*. During mating, the males closely follow the females. Normally, one male follows one female. The female moults while being followed by the male. This courting behaviour lasts for 3 to 7 minutes. Soon after moulting, the female lays her body sideways and jumps about in water bending her body ventrally when the male advances to the side of the female and embraces her on ventral side. The pair by keeping their ventral side close together swim about in the water, during which process, it is believed that the copulation takes place. During copulation, the male by means of petasma directs the spermatophores released through the openings on the fifth pair of legs to the thelycum of the female. The time spent on copulation is only 3 or 4 minutes. After copulation the male and female separate.

Prawns spawn at night, generally between 8 PM and midnight. The eggs are released while swimming in the columnar waters or near the bottom. During the process of releasing

the eggs, they bend down the body posterior to the 4th abdominal segment and show side-wise movement. The fifth pair of legs are held tightly against the body. The eggs are dispersed by the movement of the pleopods. The time required for release of eggs is very short. In some of the species such as *M. bennettae* spawning and mating are governed by lunar periodicity. Outward run takes place during new-moon cycle and spawning during full-moon phase.

Factors influencing spawning

All the commercially important penaeid prawns of India are known to breed and undergo early development in the open sea. Although these prawns enter the estuaries and backwaters in mysis and postlarval stages and attain almost all the adult characters including the development of secondary sexual characters in this environment, it is believed that the maturation of the ovary and subsequent spawning take place only in the sea. Probably environmental factors such as high salinity, low bottom temperature and greater pressure of the deeper water of the sea play important role in this phenomenon, besides the physiological changes that trigger the maturation of the ovary. Correlation between water temperature and spawning has been reported by many workers. It is shown that intensive spawning activity is generally related to rise in water temperature. Off Cochin, spawning peaks for most of the species are observed when the bottom temperature of the inshore ground increases from the lowest in July/August. Water temperature around 28-30°C and salinity of 28-34‰ are found to be suitable for the maturation of the ovary and spawning.

Induced gonadial development and spawning

Crustacean eye stalks are known to contain the endocrine centres responsible for the secretion, storage and distribution of gonad and moult inhibiting as well as accelerating hormones. With the increasing knowledge of the endocrine activity and its control of gonadial development, eye stalk ablation

technique is receiving greater attention as a possible and useful technique to induce precocious maturation of the ovary and subsequent spawning under captivity. It has been shown that the eye stalk removal of crabs is likely to stimulate either precocious moulting or precocious gonadial development depending upon the relative interaction of other ambient environmental factors and the age of the animal operated upon. Eye stalk removal also affects the normal feeding, mating behaviour of the prawns and causes high mortality. Recently it has been shown that the removal of only one eye stalk instead of both, is sufficient to induce gonad development while reducing the other effects. Although Liao (1973), Arnstein and Beard (1975), Alikunhi *et al* (1975) and Silas and Muthu (1977) have obtained varying degrees of success in inducing maturation, and in some cases, spawning by eye stalk ablation technique, it was only recently that successful maturation and spawning were achieved in *P. monodon* resulting in viable eggs which underwent normal development through postlarvae, in Philippines by this technique. The experiments involved unilateral ablation of eye stalk and showed phenomenal ovarian development from early maturing stage to mature stage within eleven days. The results of these experiments indicate great prospects of applying eye stalk ablation technique for induced spawning of prawns.

General remarks

From the foregoing accounts, it is clear that the features of reproduction such as availability of spawners rather close to shore, and during greater part of the year, spawning under captivity, fertilisation of eggs by the sperms released from the thelycum during ovulation (i.e. capability to produce viable eggs without the presence of males), high fecundity etc make these prawns ideally suitable for intensive culture. However, since the spawners are available only in the sea, their collection from the wild stock is not only expensive but also dependant on their availability as and when required. Thus, one of the major problems encountered in intensive culture of prawns is the steady supply of spawners. This problem is now being tackled in two ways. One way is to domesticate

them under controlled conditions and the other to induce their spawning by harmonal manipulations. It has been possible to domesticate *P. monodon* in the pen culture system in the inshore grounds in Philippines and to obtain spawners thus kept under controlled conditions. One of our marine prawns, *M. dobsoni,* is found to mature in higher saline backwaters, and recently they have spawned in the laboratory in brackishwater medium and the resultant eggs and larvae were raised to juvenile stage in the same medium. These experimental results on the domestication of prawns when applied on large scale, and the perfection of techniques of eye stalk ablation to induce spawning would go a long way in meeting the requirements of spawners and establishment of hatcheries for the large-scale production of seed of the desired species.

References

ALIKUNHI, K. H., A. POERNOMO, S. ADISUKURNO, M. BUDIONO AND S. BUSMAN. 1975. *Bull. of the Shrimp culture Research Centre, Japara, Indonesia,* 1: 1-11.

ANONYMOUS. 1976. Aquaculture Department. SEAFC, Philippines. *Tech. Rep.,* No. 1.

ARNSTEIN, D. R. AND T. W. BEARD. 1975. *Aquaculture,* 5: 411-12.

CUMMINGS, W. C. 1961. *Trans. Am. Fish. Soc.,* 90 (4): 462-68.

FUJINAGA, M. 1969. *FAO Fish. Rep.,* 57 (3): 811-32.

GEORGE, M. J. 1962. *Indian J. Fish.,* 9 (1): 110-16.

HEEGAARD, P. E. 1933. *Publ. Inst. mar. Sci. Univ., Texas,* 3 (1): 73-105.

HELDT, J. H. 1939. *Annls. Inst. Oceanogr. Monaco,* 18 (2): 31-206.

HUDINAGA, M. 1942. *Jap. J. Zool.,* 10 (2): 305-93.

——— AND M. MIYAMURA. 1962. *J. Oceanogr. Soc., Japan,* 20: 694-706.

KING, J. E. 1948. *Biol. Bull. mar. biol. Lab. Woods Hole,* 94 (3): 244-62.

KUNJU, M. M. 1968. *FAO Fish. Rep.,* 57 (2): 467-86.

LIAO, J. C. 1973. *JCRR Fish. Soc.*, 15: 59-65.

LINDER, M. J. AND W. W. ANDERSON. 1956. *Fish. Bull. Fish. & Wildl. Ser. U.S.*, 56 (106): 555-645.

MENON, M. K. 1951. *Proc. Indo-Pacif. Fish. Counc.*, II: 80-93.

——— 1953. *J. Zool. Soc. India*, 5 (1): 153-62.

RAJYALAKSHMI, T. 1961. *Proc. nat. Inst. Sci. India*, B, 27 (4): 179-88.

RAO, P. V. 1968. *FAO Fish. Rep.*, 57 (2): 285-301.

RENFRO, W. C. AND H. A. BRUSHER. 1964. *Circ. Fish. Wildl. Ser. Wash.*, 185: 13-15.

SHAIKHMAHMUD, F. S. AND V. B. TEMBE. 1960. *Indian J. Fish.*, 7 (1): 69-81.

——— 1961. *J. Bombay Univ.*, 29 (3 & 5): 62-77.

SILAS, E. G. AND M. S. MUTHU. 1977. Penaeid prawn culture and propagation — A critique (under publication).

SUBRAMANYAM, C. B. 1963. *Curr. Sci.*, 32 (4): 165-66.

VILLALUZ, D. K., A. VILLALUZ, B. LDRERA, M. SHCIK AND A. YONZAGA. 1972. *Phil. Jour. Sci.*, 98: 205-34.

8

REARING OF PENAEID PRAWNS UNDER CONTROLLED CONDITIONS

by

M. S. Muthu

Till recently penaeid prawn culture was dependant on the naturally occurring prawn seed in the estuarine and brackishwater environments. But availability of prawn seed from natural sources is subject to wide fluctuations and there is a world wide interest in the artificial propagation of the seed of the fast growing species of penaeid prawns. Hudinaga and his associates in Japan have perfected over a period of 30 years the technique of large-scale production of the fry of *Penaeus japonicus* in hatcheries. (Fujinaga 1969, Shigueno 1973). The Japanese method has been adopted in Taiwan to mass produce the fry of *P. japonicus, P. monodon, P. semisulcatus, P. teraoi, Metapenaeus ensis* and *M. joyneri* (Liao and Huong 1973) and in the Philippines for producing the postlarvae of *P. monodon* and *P. indicus* (Villaluz *et al* Anon 1975 a & b, Anon 1976). This method has also been used for large-scale production of the fry of *P. kerathurus* in Italy (Lumare and Villani 1974) and Spain (FAO 1975); *P. duorarum* in Florida (FAO 1969); and *P. orientalis* in Korea (Kim 1967).

The Japanese method now consists of spawning of the ripe female and rearing the larvae from the egg to the fry stage in large outdoor concrete tanks of 60-200 tonne capacity. The phytoplankton for the protozoea stages and zooplankton for the mysis and postlarval stages are developed in the concrete tank itself by adding inorganic fertilizers to the tank. Earlier the phytoplankton and zooplankton were grown separately and fed to the larvae which were reared under glass house conditions in 2m x 1m x 1m tanks lined with porcelain tiles. Over one million prawn fry are produced in a 10m x 10m x 2m concrete tank at a time. The fry production is so

high that after meeting the requirements of the prawn culturists the surplus is released into the sea for replenishing the stocks of prawns in the fishing grounds.

In the U.S.A. the fry of *P. aztecus*, *P. setiferus* and *P. duorarum* are raised in a different way. Instead of using large concrete tanks, Cook and Murphy (1966, 1969) have used plastic or fibreglass containers (1-2m^3 capacity) for spawning of the prawns. Cook (1969) has used 19-litre polyurethene carbuoys for rearing the nauplii to the postlarval stage. An air stone placed in the neck of the carbuoy circulates the water effectively. Pure cultures of diatoms and flagellates grown separately are given as food for the protozoea and freshly hatched nauplii of brine shrimps are fed to the mysis and postlarval stages. By this method 133 postlarvae have been raised per litre of water in the carbuoy. The Japanese method yields only 5-10 postlarvae per litre of sea water. The American system using an inverted carbuoy is especially suitable in places where there are no facilities for obtaining large volumes of good sea water. The Japanese method involves large capital investment for setting up the concrete installations and seawater supply systems.

To increase the survival rate of the larval stages and to reduce the cost of production, various substitutes for cultured diatoms and *Artemia* nauplii are being tried as larval food. In the Philippines bread yeast, washings of filamentous algae and juice of sargassum and even fermented extract of vegetable refuse from kitchens have been tried, with varying degrees of success. In Japan, marine yeast and finely powdered soyabean cake have been successfully used. The rotifer *Brachionus* has been found to be good for the mysis stages.

At the Narakkal prawn culture laboratory of the C.M.F.R. Institute, a very simple system has been evolved for rearing the larvae. Spawners are kept individually in 50-litre plastic basins containing 35-40 litres of sea water filtered through No. 21 plankton netting and aerated by an air stone. Spawning takes place in the night and the female is removed early in the morning. The eggs are allowed to develop undisturbed in the plastic basins. Just before the larvae moult into the protozoea stage phytoplankton, preferrably, *Thalassiosira* sp., is

added so that a concentration of 10-15 x 103 cells|ml is present in the basin. The phytoplankton is either cultured in the laboratory or collected from the brackishwater ponds attached to the farm. The phytoplankton is added to the basins every day till the postlarvae are removed. Along with the diatoms, tintinnids, rotifers and copepod nauplii occurring naturally in the pond are also introduced and form the food of the mysis and postlarval stages. Throughout the rearing period the debris found at the bottom of the basin is siphoned out and fresh sea water added every day.

Using this method all the six species of commercially important species of penaeid prawns of the Kerala coast viz. *P. indicus, P. monodon, M. dobsoni, M. affinis, M. monoceros* and *P. stylifera* have been successfully reared at Narakkal from the egg stage. The results of some of the experiments are summarised in Table 1 below:

TABLE 1

Species	No. of experi-ments	Salinity range (ppt.)	Temp. range (°C)	Total No. nauplii hatched	Total No. of postlarvae obtained after 23-30 days	Survival rate % range (mean)
Metapenaeus dobsoni	6	32.8 to 37.3	25.0 to 29.3	2,10,550	38,346	2.3 to 37.0 (18.2)
M. affinis	4	31.6 to 35.6	25.8 to 29.1	4,40,670	25,320	4.2 to 8.8 (5.7)
M. monoceros	3	34.2 to 36.2	27.9 to 29.1	12,38,740	11,880	0.8 to 1.4 (1.0)
Penaeus indicus	3	33.8 to 36.3	25.1 to 28.9	1,52,000	3,740	1.5 to 8.9 (2.5)
Parapenaeopsis stylifera	2	33.8 to 36.2	25.0 to 28.9	91,300	10,060	10.6 to 11.5 (11.0)

It was found that *M. dobsoni* could be reared very easily by the method adopted here and a survival (from the nauplius to postlarval stage) of 18.2% was achieved on an average. About 10,000 to 12,000 postlarvae of *M. dobsoni* could be produced in 35-40 litres of sea water. The poor survival observed in the case of *P. indicus, M. monoceros* and *M. affinis* was mainly due to overcrowding and the accumulation of metabolites in the medium.

The success of the method depends on selecting a really ripe female and on the care bestowed on tending the larvae. The basins and all the implements that come in contact with the water in which the larvae are reared should be scrupulously clean.

The spawners are collected from the sea with a trawl net operated for about 20-30 minutes. As soon as the trawl is brought on the deck the ripe females are sorted out and kept in buckets containing sea water. Specimens with well-developed, dark green ovaries are selected. As the ripe females are impregnated and the sperms are stored in the seminal vesicles under the thelycum, the males need not be collected. The water in the buckets is changed frequently on board the vessel and as soon as the prawns reach the laboratory the water in the buckets is well aerated and the healthy prawns are kept individually in the spawning basins.

Temperatures ranging from 24°C to 31°C and salinities ranging from 27-35‰ have been found suitable for the development of the larvae. The larvae are adversely affected if the pH of the water rises beyond 8.5. Accumulation of amonia in the water is also harmful to the larvae. They are also sensitive to ammonia concentrations above 0.2 ppm. Continuous aeration is very important; it not only supplies the oxygen needed by the larvae but also keeps the larvae and the food organisms in circulation. This prevents the larvae from getting entangled in the debris at the bottom and dying and also helps in bringing the larvae and the phytoplankton cells into contact with each other more frequently so that the food is utilised efficiently. The correct type of food organism should be made available to the larvae at every stage in their

development. Overcrowding and lack of sufficient food reduces the survival rate of the larvae.

IDENTIFICATION OF THE LARVAE

The penaeid larvae pass through 6 naupliar stages, 3 protozoael stages and a variable number of mysis stages (3-7) before becoming postlarvae. The rearing experiments at the Narakkal Prawn Culture Laboratory have enabled us to describe the complete life histories of all the six species of penaeid prawns representing 3 genera viz. *Penaeus, Metapenaeus* and *Parapenaeopsis*. This study has brought to light certain morphological features that are characteristic of the larvae belonging to each of these genera. The diagnostic characters are summarised below.

PENAEUS

Nauplius: The inner margin of the antennule has 2-3 setae, the distal one being very long.

Protozoea: The frontal organ is not overhung by pointed spine. Third maxilliped is absent in protozoea I. Protozoea II has supra-orbital spines with bifid tip. The outermost seta on each furca of the telson is dorsally placed. Protozoea III has 8 pairs of furcal spines.

Mysis: Carapace with prominent rostrum, well developed supra-orbital and hepatic spines, the pterygostomian spine sharp, no antennal spine present. Abdominal segment 4-6 with postero-dorsal median spines, the 3rd segment may also have a minute spine, the 5th and 6th segments with a pair of posterolateral spines. Uropod with the outer margin of exopod produced into a very prominent disto-lateral fixed spine beyond which the fringing setae are arranged, the outermost member of this series of setae is shorter than the distolateral spine and is non-plumose.

Postlarvae (P1 and P2): Postlarvae long and slender. Rostrum with one or two dorsal spines, supra-orbital spine present, postero-dorsal and postero-lateral spines present on

5th and 6th abdominal segments. Telson with 8 pairs of spines. Scaphocerite long and narrow, broader anteriorly than proximally. Mandibular palp cylindrical with distal segment smaller than proximal segment.

METAPENAEUS

Nauplius: The antennule has three short inner lateral setae, the size decreases gradually from the distal to the proximal seta.

Protozoea: Frontal organs overhung by pointed spine in protozoea I. Simple supra-orbital spines present in protozoea II and III. Caudal furcae short and broad, with shallow and moderate cleft and outermost pair of furcal spines slightly ventrally disposed, only 7 pairs of setae in protozoea III.

Mysis: Carapace without supra-orbital spine, but with antennal, pterygostomian and hepatic spines. Only abdominal segments 5 and 6 with dorsal spines, no lateral spines on any segment. On exopod of uropod the distolateral spine which is a continuation of the outer margin, is absent in Mysis I and is very small in subsequent stages, being shorter than the outermost movable seta which is non-plumose.

Postlarva (P1 and P2): Postlarvae small. Rostrum short with 3 dorsal spines, no supra-orbital spine. Dorsal spine present only on 6th abdominal segment. Telson with 7 pairs of spines. Scaphocerite uniformly broad in distal and proximal halves. Mandibular palp club-shaped, distal segment broader than proximal segment.

PARAPENAEOPSIS

Nauplius: The antennule with 3 inner lateral setae; up to N III, the setae are short slightly decreasing in length from the distal to the proximal seta. But in N IV to N VI the proximal seta becomes thin and greatly elongated and sharply bent in distal 1|3.

Protozoea: Frontal organ not overhung by sharp spine. Rostrum short and straight, no supra-orbital spine. Postero-

lateral spines on 6th abdominal segment inconspicuous in Protozoea III. Cleft in telson deep and wide, the caudal furcae narrow and long, the outermost pair of spines laterally disposed and separated from the penultimate pair by a wide gap. Antennules longer than antennae.

Mysis: Carapace with small supra-orbital spine at least in mysis I and II, hepatic spine absent in all mysis stages, antennal and pterygostomian spines present. Abdominal segments 5 and 6 with dorsal spines. No lateral spines on 6th abdominal segment. Exopod of uropod lacks the fixed disto-lateral spine in all mysis stages.

Postlarva (P1 and P2): Postlarvae stout. Rostrum short and curved with 3-4 spines. Supra-orbital spine absent. No dorsal or lateral spines on abdominal segments 1-5. Telson with 8 pairs of spines and a postero-median spine. Scaphocerite short and broad, broader proximally than distally, antennal flagellum longer than scaphocerite with more than 10 segments. Mandibular palp with a large oval distal segment and a smaller triangular proximal segment.

At the specific level, the larval features of the species belonging to the same genus are so similar especially in the nauplius & protozoea stages that it is difficult to identify them up to the species level.

References

Anon. 1975 a. Annual Report 1975. Mindona State Univ. Inst. Fish. Res. Develop., 1-17.

Anon. 1975 b. *Ibid.*, 19-26.

Anon. 1976. Annual Report 1975. Aquaculture Pept. SEAFDEC. Tigbauan, Philippines, 13-29.

Cook, H. L. 1969. *FAO Fish. Rep.*, 57 (3): 709-716.

——— and M. A. Murphy. 1966. *Proc. South East Ass. Game Fish. Comm.*, 19: 283-288.

——— and ——— 1969. The culture of larval penaeid shrimp. *Trans. Am. Fish. Soc.*, 98: 751-754.

Fao. 1969. FAO Aquaculture Bulletin, 1 (2): p. 7.

——— 1975. FAO Aquaculture Bulletin, 7 (3-4): 8-9.

FUJINAGA, M. 1969. *FAO Fish. Rept.*, 57 (3): 811-832.

KIM, K. D. 1967. *Proc. Indo-Pacif. Fish Coun.*, 12 (2): 253-257.

LIAO, I. C. AND HUANG, T. L. 1973. Coastal Aquaculture in the Indo-Pacific Region. Fishing News (Books) Etd., London, 328-354.

POWNALL, P. C. 1974. Australian Fisheries, 33 (5): 11-13.

SHINGUENO, K. 1973. Coastal Aquaculture in the Indo-Pacific Region, 282-312.

VELLALUZ, D. K. *et al* 1969. *Philippine J. Sci.*, 98 (3-4): 205-233.

9

SEED PRODUCTION

by

N. Neelakanta Pillai

In traditional brackishwater prawn farming in India (paddy and prawn farming in Kerala as well as the culture of prawns in impoundments called 'bheris' in West Bengal) stocking is mainly done by natural process. Postlarvae and juveniles of prawns enter the fields during the rising tide. Since the occurrence of young prawns fluctuates widely from place to place and from season to season, the rate of stocking is beyond control. Moreover a large number of predators are also brought along with the juvenile prawns by the incoming tide, which reduce the actual productive potential of these ponds. Estimated prawn production in paddy field prawn filtration in Kerala is 800 to 1000 kg/ha/year and that of Bengal 100-300 kg/ha year.

The productive potential of these fields can be increased considerably by selective stocking. For selective stocking, prawn seeds of the commercially important species can be

obtained either by collecting them from the natural environment or by making the gravid females of the desired species spawn in the laboratory and rearing the eggs to post-larvae under controlled conditions.

As the commercially important penaeid prawns in India breed throughout the year, postlarvae of these prawns can be collected from the surf region throughout the year. They can be easily collected using thick nylon netting. Nets measuring 2 metres long and one metre wide with two sticks sewn to the two ends, are used for this purpose. Two persons holding the net on two sides, can easily wade in waist-deep water in the surf region holding the net against the flow of the surf. For 10 minutes the net is dragged like this. Then the live postlarvae collected in the net are washed into a bucket containing sea water. Postlarvae of the commercially important prawns are sorted out from these collections and are used for stocking. This net can also be used to collect postlarvae from the canals adjoining the backwaters during low tide.

In Philippines the postlarvae of *Penaeus monodon*, which have the habit of clinging to the weeds etc are collected from the estuaries by using bunches of sea-grass (bon-bon) tied to long strings laid along the shallow bottom of the creeks. The postlarvae that cling to the grass are lifted up and shaken into conical nets and transferred to earthern pots containing brackishwater. Some fishermen specialize in collecting the postlarvae of *Penaeus monodon* and earn their livelihood by selling them to milkfish farmers, who stock them along with the milkfish.

In Kakdwip, the Midnapore type of shooting net used for collecting carp seed from rivers is adopted for collecting the postlarvae of penaeid prawns from the brackishwater creeks with tidal flow. The nets are fixed in the creeks against the tide and the postlarvae are removed from the cod-end periodically.

In Indonesia large fixed nets are used in brackishwater creeks connected to the sea for collecting the postlarvae of *Penaeus merguiensis* for stocking purposes.

Juveniles of the commercially important prawns are often collected from estuaries using cast nets and used for selective stocking. At Manakudy estuary (near Cape Comorin) juveniles of *Penaeus indicus* (61-70 mm) are caught by cast nets and used for stocking in brackishwater reservoirs of the salt works adjoining the estuary. Within 4 months they grow to marketable size of 135 mm. Estimated production rate from these reservoirs is 1134 kg|ha|year.

Owing to seasonal fluctuations, the seed collected from natural sources cannot always be depended upon for large scale shrimp farming. The only way to get a dependable supply of prawn seed is by producing them under controlled conditions. The technique of producing the seed of *Penaeus japonicus* under controlled conditions was perfected in Japan by Hudinaga. Here, gravid females of this species are collected from the gill nets or trawl net catches of the commercial fishing vessels. They are kept alive in the live-fish holds of the fishing vessels and brought to the shore. From there they are transferred to tanks containing sea water and brought to the hatchery by trucks. Females with ovaries which are thick and well defined are selected and transferred to breeding tanks. These tanks are square or rectangular concrete ones, measuring 2 metres in depth and holding capacity 100 m^8. The bottom of the tank is inclined to one side and a drain pipe with valve is fixed at that side. A collecting pool 2 m x 2m x 2m wide and 0.4m deep is so located to receive the end of the drain pipe for collecting the fry reared in the tank. The breeding tank is filled with filtered sea water. Proper aeration — by setting one air-stone for each 3 m^2 of tank bottom — is given. 50-60 gravid females are kept in this tank. Temperature is maintained at 28°C. Spawning takes place during night. During spawning the females move about very rapidly. Majority of the females spawn either in the first or second night. All prawns are removed from the tank after two days. About 50% of the eggs hatch out after 14-15 h of spawning. The tank water is fertilised during this time, in order to accelerate the growth of diatom on which protozoea and other larval stages feed. For the first 10 days, daily Potassium nitrate and Potassium phosphate at a concentration

of 2 ppm and 0.2 ppm respectively are added. Larvae remain in the nauplius stage for about 35 h and then metamorphose into the protozoea stage. This is a critical stage in the development of larvae. If substantial amount of phytoplankton is present in the water they develop fast and pass on to the next larval stage — mysis — after 4 days. At this stage in addition to phytoplankton they readily take zooplankton such as veliger, trochophore, nauplii of barnacles and copepods and polychaete larvae. Mysis develop into first postlarvae within 3 to 4 days. During the last mysis stage substantial amount of brine shrimp nauplii is given as food. Early postlarval stages are highly carnivorous and their growth depends on the amount of food supplied. At this stage one postlarva takes 46-84 brine shrimp nauplii within 24 h. 500 grams of brine shrimp egg are necessary for a 100 m^3 tank where postlarvae are reared, assuming 50% of the eggs hatchout. Postlarvae, 20-25 days old having a total length of 15 mm are transferred to the nursery ponds. For transportation, postlarvae are transferred in polythylene (transparent) bags with sea water and oxygen, and several bags are packed in a carton box. 6,000 postlarvae are kept in 8 litres of sea water and 4 litres of oxygen gas. They can be kept like that for 12 hours. From one gravid female 25,000 postlarvae are obtained. Postlarvae stocked in nursery ponds are fed 2 to 3 times daily with crushed meat of bivalve. Within 40-45 days they become juveniles. They are then transferred to rearing ponds for further growth. 20-25 juveniles in $1m^2$ of water is the stocking rate. Movement of juvenile prawns on the bed, during day time is a sign of food shortage or other unfavourable conditions.

The use of large concrete tanks has also been adopted in Taiwan for the mass culture of postlarvae of *P. japonicus*, *P. monodon*, and *P. semisulcatus* and in Philippines for the culture of *P. monodon* and *P. indicus*. In U.S.A. artificial propagation of *P. aztecus*, *P. duorarum*, and *P. setiferus* has been successfully achieved by adopting slightly different techniques. Instead of large concrete tanks, plastic or fibreglass containers of 1-2 m^3 capacity is used for the spawning of prawns. 19-litre polyurethane carbuoys are used for rearing the nauplii to the postlarval stage. An air stone placed in the

neck of the carbuoy circulates the water effectively. Pure cultures of diatoms and flagellates are given as food for the protozoea stage, and freshly hatched nauplii of brine shrimp are added when the mysis stage is reached. By this method they were able to rear 2000 postlarvae in 15 litres of water.

Experiments conducted at the Narakkal Prawn Culture Laboratory of the Central Marine Fisheries Research Institute helped to evolve a simple system for the production of prawn seeds of the commercially important penaeid prawns of Cochin. Gravid females of *Penaeus indicus, P. monodon, Metapenaeus dobsoni, M. affinis, M. monoceros* and *Parapenaeaopsis stylifera* collected from commercial trawl-net catches, as well as from experimental trawl-net operations conducted by the research vessels of the Institute. Fully mature specimens are then sorted out and brought to the laboratory in big carbuoys, containing sea water. Sea water in the carbuoys is changed periodically. In the laboratory, the gravid females are kept individually in 50-litre plastic basins containing clear filtered sea water of 33 to 35.0‰ salinity. The water is aerated continuously. Most of the specimens spawn on the first night itself. As soon as spawning is completed the the prawns are removed from the basins. In some cases only partial spawning is observed. 10-17 h are taken for the eggs to develop and hatch out to first nauplii. 35 to 48 h are taken for the nauplii to develop to the next stage of protozoea. Just before the last nauplius stage metamorphoses to first protozoea, enough phytoplankton is added to the basins containing larvae. 10-15 x 10^3 cells ml of phytoplankton is sufficient for the healthy development of larvae. Phytoplankton such as *Thalassiosira, Navicula, Pleurosigma* and *Nitzschia,* which are mainly collected from the brackishwater ponds adjoining the laboratory, are used. Everyday enough phytoplankton is added once. Before adding this, 1|3 of the water in the basins along with the bottom sediments are siphoned out carefully without disturbing the larvae. Freshly collected clean, filtered sea water is added to make up the level. 4 to 5 days are taken for the protozoea to develop to the next stage — mysis. Mysis of *M. dobsoni,* and *M. affinis* thrive very well with phytoplankton. But for other species, along with this, zooplankton

collected from the backwater is also supplied. The common zooplankters given are the adults and larvae of rotifers and copepods. Freshly hatched nauplii of *Artemia* are also supplied whenever available. Within 5 to 10 days they develop into first postlarvae. The postlarvae are fed with artificial food for 10 days and then stocked in the ponds.

A major bottle neck in large-scale production of prawn seed is the difficulty in obtaining spawners throughout the year. To overcome this, efforts are now being made in different parts of the world, to induce the adult prawns to attain full maturity by artificial means under controlled conditions.

10

MASS CULTURE OF PHYTOPLANKTON

by

R. S. Pandey

Mixed phytoplankton in the marine or freshwater environments will not be readily available for experiments or for feeding of animals reared in the laboratory. Hence, unialgal cultures have to be developed artificially. Pioneering work in this field was done by Miquel in Germany and Allen in Plymouth more than seven or eight decades ago. Since then much progress has been made in the development of artificial media, and mass culturing of selected organisms. This account briefly reviews the work carried out in this direction.

Methods of isolation of unialgal cultures

Isolation can be done by one of the following methods:

1. Pipette method: Larger organisms can be pipetted using suitable pipette with narrow opening.

2. Washing method: Repeated washing with sterile medium eliminates zoospores of unwanted organisms and large numbers of bacteria.

3. Dilution method

4. By exploiting the phototactic movements

5. By using solid medium in petri-dishes.

Since phytoplankters are very small in size, it is very difficult to handle them in culture, particularly during isolation. To avoid this uncertainty, the last method proved better than any other mentioned technique.

Preparation of solid agar petri-dishes and culture tubes

1.5% agar is added to 1 litre of suitable medium or even natural sea water. This agar solution is sterilized in an autoclave for 15 minutes under 15lb. pressure and 121°C temperature. Now, this medium is poured in sterilized petri-dishes and left for 24 h. In case of culture tubes, the medium is poured in 1/3 part in tubes and properly plugged with cotton before autoclaving. Sterilized culture tubes are placed in slanting position for cooling.

Isolation

Algal growth from enrichment cultures or if in abundance in natural samples can be picked up by platinum needle or platinum loop under microscope and finally streaked on the surface of agar plates. Innoculated petri-dishes are examined to ascertain the presence of desired organisms. After innoculation these petri-dishes are placed in an incubation chamber for two or three days or more, under 14/10 h light and dark photoperiods, light intensity is maintained approximately 1000 — + 100 lux. and temperature is also maintained at about 20-30°C. These petri-dishes could be observed regularly to locate the growth of a particular organism and then transferred to fresh ones using the same technique. After repeated transfers, unialgal culture could be obtained. These cultures are then maintained in culture tubes for laboratory studies.

Mass culturing of phytoplankton

If a particular planktonic alga is to be raised in mass culture, the unialgal culture obtained by the isolation technique is transferred in culture tubes containing suitable sterilized medium, and then placed in an incubation chamber under required light and temperature conditions; pH and salinity is maintained accordingly. Stock cultures can also be maintained in 200-ml conical flasks. After 3 or 4 days, these growing cultures are poured into 1-litre conical flasks. These freshly innoculated flasks are placed in the same culture conditions. After one week sufficient concentration of growing cells can be achieved. At this stage these stock cultures can be poured into glass carbuoys or fibreglass tanks containing boiled and filtered sea water enriched with Miquel's solution and kept under suitable light and temperature conditions. In such big culture-containing vessels proper aeration is given by using air compressor which helps in mixing of the culture medium preventing the settling of phytoplankton on the bottom of the container. Increase in cell numbers in such culture follows a characteristic pattern and the following phases can be observed:

1. Lag phase: No increase in cell numbers occur.
2. Exponential growth phase: In which, cell multiplication is rapid and cell number increases in geometric progression.
3. Phase of declining relative growth.
4. Stationary phase: In which, cell numbers remain more or less unchanged.
5. Death phase.

Harvesting is done at the exponential growth phase. Cultures can be maintained by occasional replacement with nutrient or by regular subculturing. If cultures are contaminated by any other organism, like filamentous blue-green algae, they can be neglected and fresh innoculum can be used for next culture.

Problems and precautions in mass culturing

1. Selection of a particular planktonic organism for culture could be made mostly from seawater samples, where prawn larvae occur, so as to make it more acceptable to the larvae.

2. Experiments could be conducted in the laboratory for their food values and suitability for larvae. Unsuitable and toxic plankton should not be considered for mass culturing.

3. Before raising mass culture, organisms can be tested for their suitable requirements such as nutrients, light, temperature, salinity and pH for rapid growth, on small scale in the laboratory.

4. If possible, zoosporic phytoplankton can be considered first for mass culturing. Such types of algae can grow rapidly due to large number of cells formed in one generation depending on the number of zoospores produced per cell. Suitable chemicals can also be used to induce cell division and vegetative reproduction for quick growth of cultures.

5. Much attention should be given to avoid possible contaminations especially with filamentous blue-green algae and bacteria as both these are unsuitable as larval feed.

6. Unialgal cultures and suitable combinations of controlled mixed cultures can also be tried for feeding. Besides, different cultures can be tried for different stages of larval growth.

7. Efforts can also be made to ensure better growth of phytoplankton cultures together with prawn larvae in the same basins to avoid unnecessary care and labour.

Role of phytoplankton in rearing of prawn larvae

Rearing of prawn larvae in the laboratory on mass scale is completely dependent on suitable food. It is well known that early larval stages, particularly protozoea are totally

dependent on phytoplankton, and mysis on phytoplankton and zooplankton. A rich supply of phytoplankton not only ensures better growth and survival of the early stages of prawn larvae, but also favours production of other planktonic animals on which the postlarval prawns depend for further development.

Apart from forming food, the phytoplankton helps in regulation of natural environment as follows:

1. Besides other higher algae, phytoplankton helps in maintaining O2 balance in the water by photosynthesis.

2. Phytoplankters, being primary producers, regulate the food chain.

3. Phytoplankton helps in purification of sewage water and other polluted bodies; they grow in polluted water and help to provide O^2 for bacterial decomposition of organic compounds into inorganic form to make it available for living organisms.

4. As a source of some antibiotics, such as Chlorellin — from *Chlorella* species. *Chlorella* is considered as a good diet for human beings as it contains about 30% proteins.

11

FEEDING LARVAL AND JUVENILE PRAWNS IN CULTURE OPERATIONS

by

C. Merrylal James

Adult prawns consume a variety of food items, although their preferences vary from species to species, based on which the prawns may be categorised broadly into herbivorous, carnivorous and omnivorous. However, often a species or even a

single individual may show overlapping feeding habits depending on the availability of food. The most interesting feature of prawns is the different food requirements during different stages of their life. This varying food habits in different life stages pose certain problems to culturists, who for successful culture, should provide the correct type of food in right quantity.

The first larval stage of the penaeid prawn, namely, the nauplius, does not require any food as they grow on the reserve food contained in their body in the form of yolk. The next stage, the protozoea, feeds on minute food organisms, mainly phytoplankton, as their oral appendages are not fully developed for the capture of larger food organisms and they have simple alimentary system. As the protozoea metamorphoses into the mysis stage, it starts feeding on small animal food organisms occurring in plenty in the ecosystem in which they live. During the postlarval stages, which follow the mysis stage, the mouth parts and chelate legs get fully developed, and from this stage onwards, the prawn is capable of feeding on a variety of animals as well as vegetable matter. It then settles down to the bottom and brouses on the substratum. The natural food of larvae, from mysis stage onwards, consists mainly of zooplankton, including rotifers, copepods and copepodites, very small worms and larval stages of various aquatic invertebrates. In the absence of living food, minute pieces of organic material, especially those of animal origin (fish, prawn, crab, mollusc, etc.) are readily eaten. In Japan successful rearing of *Penaeus japonicus* on a large scale was first achieved using cultures of the diatom *Skeletonema costatum* as food for the zoeal stages, *Artemia* nauplii for the mysis and postlarval stages and crushed clam meat for the juveniles (Hudinaga 1967). *Artemia* nauplii are considered the best food for the mysis larvae and the pelagic postlarvae (Hudinaga and Miyamaura 1962, Hudinaga and Kittaka 1966). However, all over the world, experiments are in progress on the mass culture of other food organisms. In Japan, good results also have obtained with the rotifer *Brachionus plicatilis* as a feed for the prawn larvae (Mock 1971).

Culture of brine shrimp

The nauplii of the brine shrimp (*Artemia salina*) are widely used as a feed for rearing larvae of several marine fishes and prawns. In fact, the success of rearing-technology greatly depends on the availability of *Artemia* nauplii. Apart from being easy to handle, the eggs of the brine shrimp are capable of being dormant over a long period and hatching out readily when suitable conditions are given.

It is widely distributed and is found in the salt pans and salt lakes throughout the world. The eggs in the brood pouch develop into either free-swimming nauplii (ovoviviparous reproduction) which are set free by the mother, or when reaching the gastrula stage, they are surrounded by a thick shell and are deposited as cysts measuring 0.2 to 0.3 mm in diameter, which are in diapause (oviparous reproduction). The eggs are generally collected from the natural source, dried and stored in containers in a cool and dry place. When introduced into normal sea water, they hatch out within 48 hours at room temperature into tiny nauplii. Instead of sea water, a solution prepared from 2 teaspoonful of common table salt dissolved in one litre of fresh water can also be used as a medium for hatching eggs. It is of paramount importance that after hatching, *Artemia* nauplii be separated from the unhatched|empty cysts, since the empty brine-shrimp shells interfere with the digestion of the prawn larvae and there are reports of even blockage of the gut. The positive phototactic behaviour of the nauplii can be exploited for this separation.

Sorgeloos *et al* (1977) have deviced a technique to remove the outer layer of the cyst shell (Chorion), which contains haematin, by an oxidation technique. According to this, the dry cysts are hydrated in a funnel shaped container in tapwater and kept in continuous suspension by aerating from the bottom. After one hour, the suspension is diluted with an identical volume of hypochlorite solution to reach a concentration of 2.12% of the active product. The oxidation process starts immediately and within 7 to 10 minutes, the chorion will disappear completely, which can be observed by a gradual colour change of the cysts from dark brown through white

to orange. The decapsulated cysts are filtered off immediately and should be washed thoroughly to remove all traces of hypochlorite. The treated eggs can be directly incubated for hatching or, after dehydration in a brine solution, can be stored for later use. The dehydration is performed by transferring the decapsulated cysts for 2-3 h into a saturated NaCl-tapwater solution and after that they are stored in small vials with saturated brine solution.

Although the main source of *Artemia* eggs continues to be the natural grounds in the salt pans lakes, attempts are now being made to culture them in the laboratory so as to ensure a steady supply of eggs and nauplii as and when required. In this direction, considerable progress has been achieved in the marine prawn culture laboratory of the CMFRI at Narakkal, where it has been possible to maintain generations of *Artemia* under laboratory conditions. The brine shrimp can easily be maintained in fibre glass tanks or plastic pools containing sea water. Yeast and unicellular algae are given as food to the young brine shrimp.

The penaeid prawn larvae from mysis stage onwards are reared by feeding on *Artemia* nauplii or other zooplankters. For healthy development and greater survival of larvae, abundant supply of *Artemia* nauplii must be ensured. It has been found that on an average an early postlarva devours 80 brine-shrimp nauplii per day. Assuming a hatching rate of *Artemia* eggs to be 50%, it is estimated that about 5 kg of *Artemia* eggs along with 70 kg of minced bivalve meat are required to raise one million advanced postlarvae 20 days old.

Culture of zooplankters

Zooplankters, such as copepods, rotifers, larval stages of molluscs and small crustaceans are also suitable for feeding prawn larvae. As the zooplankters feed on phytoplankton, they are generally cultured along with phytoplankton in the same container. To ensure good growth of phytoplankton which in turn steps up production of zooplankters, chemical fertilizers such as potassium nitrate (KNO_3) and potassium phosphate (dibasic) (K_2HPO_4) are added to enrich the

culture medium. In large-scale culture of larvae as practised in Japan and recently in Philippines, the fertilizers are added directly into culture tanks when nauplii are developing, so that as the nauplii metamorphose into protozoea, good growth of phytoplankton is obtained, and as protozoea passes on to mysis stage, zooplankton is produced. In Philippines, about 100 tons of water is fertilized every day with 50 kg of pottassium nitrate and 5 kg of pottassium phosphate till a bloom of phytoplankters occurs and then the amount of fertilizers will be reduced. In Japan these chemicals are added at a concentration of 2 and 0.2 ppm respectively to begin with, and thereafter, the concentration of the chemicals is adjusted depending on the blooms of diatoms. The mysis stage is reared by feeding on a mixed diet consisting of diatoms and zooplankters such as young oyster larvae, rotifers, veligers, trochophores, balanus larvae, copepods. copepodites and polychaete larvae. In our experiments it has been found that for the successful development and survival of mysis larvae of *P. indicus,* it is essential to feed them with adequate quantities of newly hatched *Artemia* nauplii or other food animals such as copepods, rotifers, etc.

References

HUDINAGA, M. 1967. Kuruma shrimp (*Penaeus japonicus*) cultivation in Japan. *FAO Fisheries Rep.*, 57 (3): 811-832.

HUDINAGA, M. AND J. KITTAKA. 1966. Studies on food and growth of larval stage of a prawn, *Penaeus japonicus*, with reference to the application to practical mass culture. *Inf. Bull. Planktol. Japan,* 13: 83-94.

——— AND MIYAMOURA. 1962. Breeding of the Kuruma prawn (*Penaeus japonicus* Bate). *J. Oceanogr. Soc., Japan,* 20: 694-706.

MOCK. 1971. United States — Japan Natural Resources Aquaculture Panel Meeting. October 14th-19th. 1971. *Trip Rep.*, 34 pp.

SORGELOOS, P. AND E. BOSSUYT. 1977. Decapsulation of *Artemia* cysts: a simple technique for the improvement of the use of brine shrimp in aquaculture. *Aquaculture* (in press).

12

ARTIFICIAL FEED

by
M. M. Thomas

Supplementary feeds are used in prawn culture to increase the growth rate so that prawns can be harvested in a shorter duration. These feeds can be either natural items or artificial feeds compounded as per the requirements of the prawns. Although natural food items such as clams and mussels have very good conversion values, the difficulty to get these in large quantities regularly all through the seasons and their easily perishable nature make artificial compounded food more suitable for use in prawn culture.

The main aim of an artificial feed for prawns is to produce as much increase as possible in the body weight of the prawns with the cheapest raw materials available so that the use of such feeds in prawn culture practices become economical on a large scale. The standard feed should contain sufficient quantities of carbohydrates, proteins, fat, minerals and vitamins to promote growth under normal conditions. The cheapest source of carbohydrate available locally is tapioca. Similarly, fishmeal provides good protein at cheap rate. Minerals could be supplied by any of the mineral supplements used in poultry such as Starmin P.S. or Eggomin. Vitamin also could be added in the form of the many animal vitamins formulations such as Rovimix, Rovisol, Terramycin nutritional formula, etc., available in the market for use in poultry and livestock. Besides the normal nutritional ingredients of these diets, certain quantity of crude fibre which cannot be digested by prawns but at the same time increases the bulk of the feed to facilitate easy movement of the feed inside the digestive track is essential. This purpose will be served by the rice bran or wheat bran, although they provide small amounts of vitamin B also.

The artificial feeds will have to be produced in pellet form as prawns are in the habit of holding the food while feeding. The pelletising can either be done by using binding agent like agar-agar or by making a paste out of the tapioca powder by boiling with water and then mixing the other ingredient with this paste to make the dough of required consistency. The pellets should sink in water quickly at the same time keeping the shape for at least a few hours till they are consumed completely by the prawns. For postlarvae, smaller pellets are better suited.

Preparation of artificial feed

The ingredients are sewed and the required quantities of each item are mixed with the binding agent solution and the soft dough passed through the mixing machine with die having holes of 3-mm diameter. The strands are received in enamel or stainless-steel trays and dried at 70°C in hot-air oven or sun dried in summer season to a moisture content less than 10% and stored in air tight containers. The strands after drying can be broken into smaller pellets of 3-5mm length to suit the prawns. For large-scale production of feeds pelletising machines will have to be used according to the daily requirements.

These feeds could be simply thrown uniformly into the pond at the rate of 5-10% of body weight of the prawns stocked increasing the quantity as the prawns grow. Feeding can be best done in the evening as the prawns are more active during the night. If necessary, the total quantity of feed could be divided and given once in the morning and again in the evening. If the exchange of water due to tidal effect is not considerably high there is a possibility of oxygen depletion at the bottom due to excess food being decayed. If this happens, half feeding can be done in the morning and the rest in the evening.

The importance of artificial feeds in prawn-culture practices has been fully realised in many of the advanced countries of the world where many research projects are at present undertaken to study the various aspects of the nutrition of

prawns although very little has been done in India. Studies in this line were initiated in the Central Marine Fisheries Research Institute, Cochin, in 1972 and considerable informations have been acquired on the nutritional requirements of Indian prawns during the least few years. Nineteen feeds have been compounded with different proportions of the ingredients and these have been tried on different species of Indian penaeid prawns under laboratory conditions. The effects of increase and decrease of protein and carbohydrate have also been investigated on postlarvae and juveniles. It has been found that protein content much less (23%) than those recommended by Japanese workers (40-60%) was sufficient for good growth in our species under local conditions (Thomas *et al*, M.S.). The energy conversion of best feed also has been determined and the energy budget estimated for *Metapenaeus dobsoni*. The feed gave mean assimilation efficiency of 80.99% while mean gross conversion efficiency was 39.62%. The consumption rate per day in percentage body weight was 12.16 with mean growth rate per day in percentage body weight of 8.507.

Energy budget

Consumption (100.00%)	Assimilation = 80.18%	Growth = 38.79% Moult = 00.60% Metabolism = 40.79%
	Faeces = 19.82%	

13

PRAWN FARM

by

S. Ramamurthy

Several physical and biological risks are involved in prawn farming which have to be surmounted by suitable management systems to make it a viable enterprise. There are many species of prawns each with somewhat different enviornmental requirements. Aquaculture, like agriculture, cannot be carried out just anywhere. The site must have certain natural ameneties like ample supply of quality water and soil and availability of seed prawns. It is also necessary that the farmer exercises control over the site through ownership, lease or other means of secure holding.

1. *Classification of farms*

Depending on the water conditions, the sites suitable for prawn farming can be classified as marine, estuarine and freshwater. The last mentioned is beyond the purview of the present subject matter.

(a) *Marine farms*: These are salt-water farms located in the coastal areas which are largely free from the influence of river discharge. Truly marine conditions are obtained here throughout. Six different zones are recognisable in the sea of which the shore, intertidal and sublittoral zones are usable for prawn farming.

Shallow coastal lagoons, which remain disconnected with the sea for a major part of the year are said to be poor in biological productivity due to several factors such as poor quality of soil, meagre organic content, low nutrient level and high saline conditions.

Waste water released by the power plants may play an important role in marine farming particularly in the northern latitudes to create year-round summer conditions in the ponds. One of the waste products is flue gas containing high concentration of carbon dioxide which can increase the algal production.

(b) *Estuarine farms*: These include the mud flats, swamps, *bheris* and the paddy fields of Kerala and West Bengal situated in the vicinity of the confluence of the river and sea. It is well known that the estuary is a very complex environment representing a transition from the marine to freshwater zones. One of the most prominent characteristics is the dynamic nature of the processes taking place which result in marked changes in temperature, salinity and pH. Towards the seaward end, the physical and chemical conditions are more or less marine. But these conditions change with the season, freshwater or near freshwater conditions prevailing during the monsoon because of the rain-fed rivers. In some places, estuaries receive little rain water and may have salinities similar to the sea.

The shallow estuarine muddy bottoms and tidal marches are of particular importance to the fish farmers, since they are regarded as the most fertile areas, their biological production rating as high as 20 times that of the open sea. In spite of the high fertility, not all the organisms are culturable in these areas.

Several factors determine the success of farming such as location of enclosures, tidal amplitude in relation to the site elevation, quality of water and soil, availablity of seed prawns and predator control.

2. *Selection of farm site*

(a) *Topography*: The most desirable location is along tidal flats and marsh lands adjacent to brackishwater estuaries. Sites of irregular shape and uneven bottom contours are not desirable since they reduce the efficiency of harvesting. Sites located too near to the beach are likely to be subject to the threat of erosion. At least a fringe of 15 m should be left between the sea and the farm to ensure protection from erosion.

The area chosen should have a sufficient range of tidal movements to allow minimum of 0.7 m of water in the pond at all times of the year. A tidal range of 1.5 m is considered necessary to ensure a free tidal flow. The elevation of the site should not be too high nor high tides too low for the elevation. The bottom should be above low-water neap tide level to enable complete drainage of the pond.

In the sublittoral zone, the main criterion for selection of site is that variations between high and low water levels should be small and there should be enough circulation of water within the farm enclosure at neap tides.

(b) *Water quality*: A constant supply of clean high quality water must be available to exchange or to replace the water lost through evaporation, seepage and drainage during management operations. The water should be free from hydrogen sulphide, pollutants and other contaminants. It should be rich in nutrients and dissolved oxygen (minimum aceptable level of 02 is 3.5 ppm in the pond). The temperature and salinity conditions of the water should suit the physiological requirements of the species. The optimum conditions are considered to be 25.30°C and 25-33% respectively.

(c) *Soil quality*: The soil quality is not always of prime consideration since the fertility of the soil can be made good by using organic manure|fertilisers or by resorting to supplemental feeding. However, soils high in clay composition with a pH of 6.5-7.5 are usually suitable since they tend to hold water. The clay particles absorb calcium and potassium salts from the sea water making the soil rich in minerals. The organic matter brought in by the tides disintegrates and adds to the fertility of the soil to promote rapid growth of algae. Mixed clay and sand with enough silt to fill up the spaces is also considered suitable. But there should not be more than 50 cm of silt on the bottom, since for unknown reason, heavy silting reduces prawn production. Similarly large amounts of organic matter are to be avoided since they are likely to produce anaerobic conditions or decay leading to mortality of prawns.

Sometimes, the pond bed may contain black soil which is due to the formation of hydrogen sulfide. To control this, slag from copper refinery (70% Fe0) can be spread on the pond bed, which changes the H_2S into nontoxic iron sulphide.

(d) *Availablity of seed*: The naturally occurring species in a given area would most likely dictate the species to be cultured in that area. Therefore, before selecting a site, its suitability for culture should be evaluated. For this purpose, it is necessary to make trial fishing by cast net to determine the relative abundance of the various species. If large numbers of nonpenaeid prawns are captured, then the site is likely to be unsuitable. Further, the location of the site depends partially on the method of obtaining seed prawns for cultivation. Prawns suitable for farming include species which can be raised from the eggs to adult in captivity and those the young ones of which must be obtained from the natural habitat. In many farms, young prawns brought by the incoming currents are kept in impoundments for rearing. In other farms, where stocks are collected from the sea and then placed in impoundments, pond location is not as critical as in the first method in which the tidal currents bring the stock. However, culture operations which depend on the wild stock of seeds are ultimately limited by the success of reproduction.

(e) *Other factors*: For an economic operation, the surface area of site available should be not less than 5 ha. The site should be easily accessible by road at all times to the culturist as well as to the market for disposal of the catches. This may encourage poachers but they can be readily detected.

Land free from dense vegetation such as mangrove forests can be more easily and economically converted into farms.

3. *Construction of fields|farms*

The conventional farms utilised for prawn-cum-fish culture are the *bheris* of West Bengal, the paddy fields of Kerala (*Pokkali* fields) and West Bengal. The *bheris* are brackish-water impoundments into which tidal waters are admitted through improvised or permanent sluices. In the channel, inside the sluice gate, split bamboo screens shaped like an inverted

'V' or 'W' are fixed in such a manner as to allow the seeds into the enclosures during high tide and prevent their escape during low tide. The paddy fields are utilised only seasonally. In West Bengal, the water level in the irrigation canals is maintained about 30 cm below the level of the fields until the outbreak of monsoon in June or July by which time the fields are manured and paddy seedlings are planted. When the canals become flooded due to rains, bunds surrounding the fields are broken at selected places and fish and prawn fry are allowed to enter the fields where they grow during the paddy cultivation period until harvest. In Kerala, the low lying paddy fields are utilised for trapping young prawns and fishes after harvesting the crop. In October, the bunds provided with wooden sluices are strengthened and the prawn and fish fry enter the fields along with the high tide. A conical bag net with a rectangular frame mouth is tied to the sluice gate to prevent the escape of prawns. Prawn harvesting commences after 3 months.

The simplest and least expensive type of construction of farms consists of erection of short fences or gates across the narrow exits from estuaries or lagoons. In the Malay Peninsula, prawns brought in by tidal currents are trapped in such special enclosures until harvest. The most expensive construction involves completely enclosing a portion of a tidal flat. The dikes surrounding the impoundments are usually constructed of soil taken from within the enclosure. Such ponds are known as dugout ponds. The other type of ponds are (i) the levee pond where the water is retained in the desired area by construction of a dam or levee and (ii) the artifical ponds constructed of cement concrete or wood.

The sublittoral zone can be utilised with netted enclosures. Though initially this may be an inexpensive method, the maintenance cost runs high. Prawn farming in sublittoral waters is in vogue only in Panama city, Florida (U.S.A.). The creosote coated (antifouling) mesh netting barriers are suspended from the cables strung between piles driven into the sea bed.

(a) *Dugout ponds*: In their construction, the best use of the tidal flow is made to flush out the waste products from

the enclosures, to bring in food and dissolved oxygen and to cycle the nutrients. It is ideal to exchange about $\frac{1}{4}$ of the volume of the water in the pond at each tidal cycle. Mangrove stumps, if any have to be cleared since they form hiding places for the predators.

The dikes should be strong to withstand tidal and wave action and the stress of water pressure from within at low tide. Grass'mangroves can be planted often along the dikes to prevent erosion due to wind and wave action. The dikes should be at least 50 cm above HWM to prevent overflow. They should also be wide enough for the presonnel to walk. They are to be built with the mud excavated from the pond. Hard clay is preferable as it is impermeable to water. Otherwise the soil is to be treated with various sealants like bentonite but only at considerable expense. Bentonite (clay) is particularly useful for sandy or silty soil. It has the property of absorbing large amunts of water and expanding 8-20 times its original volume, thus plugging the pores in the soil. It is preferable to apply this when the pond is dry. Hay may be used to minimise cracking of the soil. Chemical sealants like sodium polyphosphates can be mixed to prevent leakages in pond constructed of fine grained soil. Of particular importance is the compaction of the soil on the bunds and preferably the pond bottom also. Compaction of the bottom can be done mechnically by using a roller. Dikes should be formed in layers of soil and each layer should be dried or sun baked before the next layer is added on the top. The horizontal basal measurement of the dike should be 1.25 to 1.75 m for every meter rise of dike. The quality of workmanship at this stage would largely determine the amount of maintenance in the future. Even for a well constructed bund, the rate of sinking will be about 30 cm'year compared to 90 cm|year for a poorly constructed one.

The popular method of pond sealing is lining the pond with a flexible membrane of polyethylene, vinyl or butyl rubber (2-4 mm thick). These materials are structurally weak and must be handled with care. They are laid when the pond is dry. Once properly spread it keeps the pond water tight. Overlapping of strips should be 15 cm at joints and seamed with

cement or tape. The lining is anchored by excavating a trench 20-25 cm deep and 30 cm wide completely around the periphery above the water level and burying the edges of the liner in the trench with compacted backfill. To protect against punctures and tears, the liner should be covered with at least 25 cm of silty sand.

To facilitate maximum drainage of the pond. the bottom should slope towards the channel entrance of the pond. Concrete catch basins (holding ponds) are constructed at the deep and of the pond behind the sluice where the prawns would collect following the receding water. The catch basin also provides shelter for the prawns during hot weather.

The water supply to the ponds is by means of a channel linked with the estuary or the sea. The channel should be preferably straight and without plants since plants vibrating in the currents frighten away the shrimps.

In the construction of dugout ponds a variety of layouts are adopted. The ponds may be of 'linked' type constructed in a row each with or without independent water supply. Parallel ponds are those built in a single or two row series each with independent water supply. The ponds known as 'Porong' in Indonesia 'Taman' or 'Tambaks' in Indonesia and Philippines and the 'Wun' of Taiwan are constructed on these patterns with independent water supply.

Soil slabs are excavated to create ditches or channels of varying patterns extending from the sluice gate end of the pond to the farthest corners. It is believed that these channels serve as hide-outs against predators and increase the yield.

Large numbers of smaller units (0.01 ton 0.1 ha.) are advantageous than a single large unit. though construction cost is more per ha of water. Each unit could be fed independently with a feeder canal and drained separately by sluice gates fitted to each pond. Such ponds are easier to manage and harvest. If for any reason. the stock is lost in one pond. the other ponds would not be affected and thus financial loss could be minimised.

(b) *Levee ponds*: These are preferable since they can be drained completely without the use of pump through an outlet. The risk from predators is eliminated in these ponds. The ponds are fed by pumping water through an inlet pipe. The pond bottom slopes towards the outlet end. Recommended slope of the levee is 4:1 on the inside and 3:1 outside. Fruits, vegetable crops and tree size plants grown on the levees afford shade and prevent excessive growth of algae as is done in some South East Asian countries.

(c) *Artificial ponds*: These are expensive compared to dirt ponds. Growth of prawns may not be as good as in the dirt pond but can be made good by resorting to artificial feeding. Predators as well as disease organisms could be eliminated.

In Japan a 'river' type culture facility is built. A series of oblong ponds 100 x 10 m or 20 x 10 m is constructed with an outlet pipe. Rapid exchange of water is achieved by pumping out water from the end pond thus maintaining a flow of current in these ponds. Some culturists use tanks with false bottom made of fine screen which is covered with about 2 cm of sand. Air is passed through a system of stand pipes from beneath forcing water up into the tank and creating a downward circulation through sand which acts as a filter. This sort of aeration and filtration greatly obviates the need for constant interchange of water. Some others use closed race-way system where slow water movement is maintained in a particular direction using air lift pumps and fibreglass panels which divide the water mass in the tanks into narrow channels. The panels are suspended from a wooden frame work which lays across the top of the tank and are held 5 cm above the bottom. Filter buckets are used in the corners of the tank to remove waste products. The same water is recycled in this system under optimum environmental conditions. This system has several advantages like rearing prawns in crowded conditions, predator and disceasc control and uni'orm distribution of food.

4. *Engineering installations*

Sluice gates of wood treated with anti-wood-borer chemicals or concrete sluices are constructed to control the exchange

of water in the ponds. Both the open type and culvert type of sluice gates are used. But the former is however the most common and is constructed with slots to premit the use of screens and or wooden slabs. Generally they do not exceed 1.0 to 1.3 m in width as larger ones are difficult to operate against the water pressure. Where the enclosure is large, multiple gates are often installed. Although the size and arrangement of impoundments is quite variable, all have free access to tidal exchange.

The sluice gates should be so located that the rising tides would not generate whirlpools and eddies which may trap the incoming prawns. The gates can be built on gravel or concrete foundation and the sides and the bund adjoining the gate reinforced by wooden pilings. Pond bunds can be strengthened by corrugated asbestos sheets as bulkheads supported by posts at intervals. The open type gate can be operated manually or by a simple wooden windlass. In the culvert type, water pressure against a clapper mechanism stoppers the culvert when the tide drops and pushes open as the tide rises.

In all these cases screens or filters are used to keep the prawns in and undersirable species out. The simplest type of screen is made of bamboo lattice shaped like inverted 'V' or 'W' as described earlier. Fine mesh net screens are also used. In the levee ponds various types of screen filters are used on the inlet pipe. The sock type is inexpensive and durable. It is attached to the pipe by clamps on the pond side and should be long enough to extend below the surface of the water to reduce stress on the screen. Where the current is strong, it may be necessary to construct a box filter made of a rigid frame work into which the incoming water flows. The screen may be kept submerged to reduce the stress.

The filter buckets employed in the closed race-way system consists of a plastic bucket with a perforated plastic bottle bolted to its bottom. The top of the plastic bottle was cut to accomodate the airline pipe. The bucket is filled with crushed oyster shell and submerged.

If stagnant conditions prevail in the pond, accumulation of ammonia, carbon dioxide and hydrogen sulphide and low

oxidation-reduction potential would result. Though prawns could withstand these conditions, their growth would be retarded. In such instances, the water should be pumped out and replenished until normal conditions restore. As an alternative the pond water at the surface can be mechanically agitated by means of an electric wheel or propeller mounted on a floating raft to hinder zonation and serve aeration. Compressed air can also be used to aerate through air line extended into the ponds.

To control the water level or to drain the levee ponds special swivel-pointed 'L' shaped stand pipes are often used. The short leg of the 'L' is perpendicular to the bottom with the end a foot or so above the surface. In this position it acts as an overflow device in case of high water. Total or partial drainage is possible by rotating the short leg over a swvivel-joint provided at the apex of the 'L'. To overcome stagnant conditions in these ponds, the O_2 deficient bottom water can be discharged by using an outer sleeve overflow.

Care should be taken to see that all the materials used in the salt water system are chemically inert. Metal fixtures are to be avoided since crustaceans are sensitive to metal ions. PVC (Polyvinyl chloride) or nylon fixtures are good. Detergents should not be used to clean the system as they are lethal.

5. *Preparation of field|farm*

Preparation of the pond for algal growth and for the subsequent stocking of prawns often entails draining, sundrying the bottom for 2-6 weeks depending on the weather conditions and lightly tilling the bottom wherever possible. Although the latter practice is not absolutely essential, it does assist in eliminating predators which remain burried in the mud and in making nutrients in the bottom deposits more available by bringing them into closer contact with water. During this time agricultural lime (slaked lime) should be applied (400 kg|ha) to absorb excess of carbon dioxide and supply the calcium required by the prawns during their moulting periods. Water which has been screened is permitted to flow into the pond

to a depth of 3 to 8 cm to induce growth of microbenthos complex. Algal growth may be further accelerated by the addition of commercial fertilisers or else the water should be changed every few days to replenish the nutrients for the growth of algae. When commercial fertilisers are used, frequent light applications, sufficient to maintain dense algal growth are made. If organic fertiliser is to be used it is best applied (5 tons/ha) in heaps rather than spread over the bottom. In this way the nutrients are released slowly and the O_2 supply is less likely to be depleted. A wide array of organic fertilisers like rice bran, cattle and poultry dung, night soil and sewage waste are used. In parts of China it is standard pond management to raise livestock and/or poultry in conjunction with the pond — often on platforms over the water. As the algal growth increases the water level should be gradually increased until the maximum desired depth is reached. It would be desirable to drain the pond completely once in a year to increase the rate of production of microbenthos.

Undesirable aquatic species may be removed by the use of rotenone or saponin (the active ingredient of derris powder and tea seed cake respectively). This is preferably done 3-4 weeks before stocking. Fish toxicants such as mahua oil cake may also be used as substitute. The tea seed cake and mahua oil cake serve also as fertilisers. In U.S.A. 3 pounds of derris powder with a 5% rotenone content for each acre foot of water has been found to be effective in eliminating predators from ponds stocked with *Penaeus setiferus*. However, it would be desirable to test the effect of the individual toxicant on the species of prawn to be cultured and the optimum dosage required before actual use.

It may be emphasised here that the considerations given above are only of general nature. There are many species of penaeid prawns each with somewhat different environmental requirements as stated earlier. There may also be problems — biological as well as physical — connected with prawn culture, peculiar to each locality for which the points discussed above may serve as guidelines to some extent.

References

ANONYMOUS. 1972. Indian Ocean Fishery Commission Report|72|6. 9th-13th Octo.

BORRDACH, JOHN E., JOHN H. RYTHER AND WILLIAM O. MCLARNEY. 1972. "Aquaculture — the farming and husbandry of fresh water and marine organisms." Wiley-Inter Science, New York.

HUET, MARCEL. 1975. "Text Book of Fish Culture breeding and cultivation of fish". Fishing News (Books) Ltd., Survey.

IVERSEN, E. S. 1968. "Farming the edge of the sea". Fishing News (Books) Ltd., London.

JHINGRAN, V. G. 1977. "Fish and Fisheries of India". Hindustan Publishing Corporation (India), Delhi.

KESTEVEN, G. L. AND T. J. JOB. 1958. Shrimp culture in Asia & Far East. *Proc. Gulf Carribean Fish. Inst.*, 10: 49-68.

MILNE, P. H. 1972. "Fish & Shell Fish farming in Coastal waters". Fishing News (Books) Ltd., London.

MOCK, C. R., R. A. NEAL AND B. R. SALSER. 1972. "A closed raceway for the culture of Shrimp" contribution No. 363, N.M.F.S. Gulf Coastal Fisheries Centre. Galveston, Texas, USA.

SHIGUENO, K. 1972. Problems of prawn culture in Japan. *Overseas Tech. Co-operative Agency Report*, Tokyo.

14

THE ENVIRONMENTAL REQUIREMENTS FOR CULTURE OF MARINE PRAWNS

by

C. Suseelan

A knowledge of the biotic and abiotic factors affecting the cultivable species of prawns is a prerequisite for their successful culture. Of the various abiotic factors, the physical and chemical characteristics of the media in which the prawns thrive have profound influence on the successful breeding,

growth and survival. The important physico-chemical factors influencing the biological processes of these animals are briefly discussed here.

The marine prawns of India can be broadly grouped into two categories namely penaeid prawns and non-penaeid prawns. In the capture fishery, both these groups contribute in significant proportions in the overall production. However, in the culture fishery, penaeid prawns are more important than the non-penaeid prawns and have immense potentialities for large-scale culture in the coastal regions.

It is well-known that most of the penaeid prawns begin their life in the open sea and migrate to shallow coastal areas and estuaries at postlarval stages. They stay in these environments for some time growing rapidly and then return to the sea on reaching or nearing adulthood. This ontogenic movement is associated with abilities acquired at different stages to withstand the changes in environmental conditions. In the sea, the changes are relatively less and many vital activities such as maturation, breeding, early metamorphosis etc. are accomplished there. The conditions in the estuary, on the other hand, are very complex and dynamic and the juvenile life is endowed with more power to tolerate the extreme fluctuations in physico-chemical factors of such surroundings. In this ecosystem, which serves as a nursery ground for most of the species, the juveniles are extensively fished all over the country and also cultured in adjoining brackishwater enclosures using traditional methods.

The following are some of the major environmental factors influencing the prawns.

Bottom conditions: Generally the juvenile and adult prawns prefer soft muddy bottoms enriched with plenty of organic detritus and other food items. Some times sand and clay also provide satisfactory substrata for young prawns. Species such as *Penaeus duorarum*, *P. japonicus* and *P. indicus* are generally associated with sandy bottom conditions, while most of the other prawns prefer muddy areas. Though there does not seem to be any effect of water depth on the density of juvenile population, the preferred areas of their habitats are usually quite shallow.

Quality of the water and oxygen content: The quality of water in culture fields determines the quality and health of the prawns under cultivation. Turbid and polluted water would weaken the prawn stock and turn them vulnerable to diseases and parasites.

The oxygen content of the water has profound influence on the general metabolism and growth of the prawns. It has been observed in *Metapenaeus monoceros* that the rate of oxygen consumption changes in different salinity media, the oxygen consumption increasing with increasing hypertonicity or hypotonicity of the medium, and attributed this to the osmotic adaptation of the prawns (Rao 1958). In estuaries the oxygen requirements of *Penaeus indicus* change as the prawn grows and the metabolism is related to its body weight, the heavier forms showing greater dependency on the oxygen content of the water (Subrahmanyam 1962). The minimum survival level of oxygen content for this species varies from 1.49 ml/1 to 3.80 ml/1 among early juveniles and subadults respectively.

In culture operations the water in brackishwater ponds should be kept pure and free exchange of the farm water with the highly oxygenated sea water (always above 3.5 ppm) should be provided to reduce mortality and stunted growth due to oxygen defficiency. Additional aeration to the water may also be given using artificial contraptions installed in the ponds, especially during summer months when the oxygen content in the farm goes down to dangerously low levels.

Salinity: Salinity is the most important factor influencing the life history of penaeid prawns. It influences many functional responses such as metabolism, growth, migration, osmotic behaviour, reproduction etc. The adult prawns are relatively less tolerant to low salinities and invariably all of them are known to attain sexual maturity in higher saline waters of the sea. The spawning also takes place only in the sea. However, recent laboratory experiments conducted by the Central Marine Fisheries Research Institute have indicated that *Metapenaeus dobsoni* could spawn in brackishwater conditions also when the salinity is above 28‰. In Japanese culture, spawning of *P. japonicus* occurs in salinities 28 to 36‰ at temperatures 22°C-33°C.

Metamorphosis is successfully completed in the sea or in high saline media, but the postlarval forms withstand lower salinities as evidenced by their occurrence in varying conditions of estuaries and backwaters. The mysis and postlarval stages have wider adaptability to changes in salinity. In laboratory experiments, Rao (1973) noticed that the mysis of *M. dobsoni* are active up to a salinity of 16.74‰ but become inactive at salinities below 14‰ and die at 11‰. He further observed that the postlarvae of this species can withstand still lower salinity up to 5.6‰ and in salinities below this value they become weak and die at 0.9‰ In *P. japonicus*, Hudinaga (1942) observed that the lowest salinity required for the survival of egg, nauplius and zoea is about 27‰ and for mysis and postlarvae 23‰. The highest limit of salinity for egg, nauplius and zoea is about 35‰, for mysis nearly 45‰ and for postlarvae 47‰.

Salinity is the factor most commonly correlated with the distribution of juvenile and subadult penaeids in estuarine environments. Like the postlarval stages, the young prawns also tolerate extreme variations of salinity (0.2‰ in *P. aztecus* to 70.0‰ in *P. duorarum*) in these habitats and grow more rapidly than in the sea. There are divergent views regarding the growth rates of juvenile populations in estuaries and backwaters. Although these differences are not attributed specifically to any of the hydrological parameters it is possible that salinity is the dominant factor responsible for such changes, as it plays the key role in making the estuarine world very complex and dynamic. Under normal temperature conditions (26°C) maintained in the laboratory, Venkataramiah *et al* (1974) observed the best growth and survival of *P. aztecus* in low salinities ranging from 8.5‰ to 17.0‰ There are increasing evidences to suggest that an environment characterised by low salinity and high temperature or high salinity and low temperature in the optimal ranges would promote better growth and survival of the prawns. A combination of the higher values of both these factors is detrimental and not recommended in prawn culture. Under laboratory conditions, Nair and Krishnankutty (1975) observed that the growth rate of *P. indicus* is significantly high in salinity of 10‰ for postlarval stages and in salinity of 30‰ for juveline prawns.

Although the penaeid prawns can tolerate wide range of salinities, the following minimum salinities should be ensured for better results in large scale culture:

Penaeus indicus	..	4‰
Penaeus semisulcatus	..	19‰
Metapenaeus affinis	..	14‰
Metapenaeus dobsoni	..	4‰
Parapenaeopsis stylifera	..	25‰

Penaeus monodon is more euryhaline and can be raised in still lower salinities.

Temperature: Temperature of the surroundings also play important roles in the biological processes of penaeid prawns. They are known to tolerate wide range of temperature, the highest range recorded being 2.6°C to 38°C (in *P. setiferus*); but cultural practices are easier at temperatures above 15°C (Panikkar 1968).

It is generally believed that intensive spawning activities of these prawns are associated with higher temperature. In the inshore and backwater regions of Cochin, Rao (1973) observed that there is no relationship between the distribution of larvae and the temperature conditions. He, however, noticed peak abundance of larvae at temperatures ranging from 28°C to 30°C in these environments. The suitable temperature range is still wider in *P. japonicus*, whose larvae thrive well in water temperatures of 15°C to 33°C.

The influence of temperature on the survival and growth of postlarval and juvenile population is relatively more when combined with optimal salinity conditions. Laboratory studies of Zien-Eldin and Griffith (1969) have shown that combinations of low temperature and salinity are detrimental to post-larvae of *P. aztecus*. Williams (1960) has found that the juveniles of *P. aztecus* and *P. duorarum*, although inhabiting areas with wide range of salinities, survive better in higher salinities at low temperature. At high temperature, the food consumption of the former species increases, but the food is more efficiently utilised in low salinities of 8.5‰ to 17.0‰ (Venkataramiah *et al* 1974). The respiratory rate and osmoregulatory abilities also change with salinity and temperature

combinations. It has been observed that *M. monoceros* from the brackishwater habitat has a minimal rate of respiration in 50% sea water, with increase in higher or lower salinities; while from marine habitat it shows a minimal rate in sea water at normal temperature conditions (Rao 1958). The osmotic values of the prawns are generally low when they are acclimatized to high temperatures.

In brackishwater culture, a regular exchange between tidal water and farm water is highly essential to maintain optimum temperature requirements of the prawns. The ideal temperature for prawn culture is 28-32°C.

Calcium content: As the calcium content of the prawn moult is high, lack of calcium in the surroundings would affect the frequency of moulting and play an adverse part in the growth processes. In a calcium dificient environment the osmoregulatory mechanism breaks down due to defective permiability of the membranes. Therefore, the availability of sufficient calcium in the surroundings has to be taken into consideration while selecting site for prawn culture in order to ensure quick growth and moulting of the prawns.

References

HUDINAGA, M. 1942. Reproduction, development and rearing of *Penaeus japonicus* Bate. *Jap. Journ. Zool.*, 10 (2): 305-393.

NAIR, S. R. SREEKUMARAN AND M. KRISHNANKUTTY. 1975. Note on the varying effects of salinity on the growth of the juveniles of *Penaeus indicus* from the Cochin backwater. *Bull. Dept. Mar. Sci. Univ. Cochin*, 7 (1): 181-184.

PANIKKAR, N. K. 1968. Osmotic behaviour of shrimps and prawns in relation to their biology and culture. *FAO Fish. Rep.*, 57 (2): 527-538.

RAO, K. P. 1958. Oxygen consumption as a function of size and salinity in *Metapenaeus monoceros* Fab. from marine and brackishwater environments. *J. Exp. Biol.*, 35 (2): 307-313.

RAO, P. VEDAVYASA. 1973. The influence of salinity and temperature on the breeding and development of some cultivable marine penaeid prawns. *Proc. Seminar on Mariculture and Mechanised Fishing*, Madras 28-29 November 1972: 67-69.

SUBRAMANYAM, C. B. 1962. Oxygen consumption in relation to body weight and oxygen tension in the prawn *Penaeus indicus* (Milne Edwards). *Proc. Indian Acad. Sci.*, 55 (3): 152-161.

VENKATARAMIAH, A., G. J. LAKSHMI AND G. GUNTER. 1974. Studies on the effects of salinity and temperature on the commercial shrimp, *Penaeus aztecus* Ives, with special regard to survival limits, growth, oxygen consumption and ionic regulation. *Contract Report*, H-74-2, US Army Engineer Waterways Experiment Station, Mississippi.

WILLIAMS, A. B. 1960. The influence of temperature on osmotic regulation in two species of estuarine shrimps (*Penaeus*). *Biol. Bull. Mar. Biol. Lab.*, Woods Hole, 119 (3): 560-571.

ZEIN-ELDIN, Z. P. AND G. W. GRIFFITH. 1969. An appraisal of the effects of salinity and temperature on growth and survival of postlarval penaeids. *FAO Fish. Rep.*, 57 (3): 1015-1026.

15

STUDIES ON PHYTOPLANKTON PRODUCTIVITY AND THE ESTIMATION OF POTENTIAL RESOURCES

by

P. V. Ramachandran Nair, C. P. Gopinathan and V. K. Balachandran

The phytoplankters are the microscopic plant life of the sea, which constitute the primary producers synthesising the basic food. It belongs to the class algae, which besides chlorophylls, possess other characteristic pigments. The important components of phytoplankton are: Diatoms, Dinoflagellates, blue-green algae and very minute forms called the nannoplankters. In addition to these, two other classes namely, Silicoflagellates and Coccolithophores also belong to the category of phytoplankton.

The diatoms are characterised by the presence of silica on their cell walls. They constitute the major part of the

phytoplankton of the sea. Their importance lies in the fact that they are photosynthesising organisms and serve as a vital first link in the food chain, either directly or indirectly, of almost every animal in the sea. Therefore to the fishing industry they are of paramount importance. It is probably true to say that at sometime in their life-history, all fish, molluscs, bivalves and crustaceans are diatom feeders, at least in part.

What is primary production?

Primary production may be defined as the production of organic matter by autotrophic organisms using the radiant energy of the sun. In the ecological studies of aquatic environments, the dynamics of production and the quantitative aspects of the relations involved is of great importance not only to the ecologist, but also to the conservationist, the farmer and the fishermen in order to ascertain whether the actual yield represents a low utilization or an over exploitation of an area.

Methods of estimating primary production

The word 'production' is synonymously used for standing crop as well as primary production, which is basically a measure of the photosynthetic activity of autotrophic organisms viz., plankton and benthic algae and possibly photosynthetic bacteria. Various methods, both direct and indirect are employed for estimating the production of an area. Of the direct methods that are used in the measurement of primary production, the oxygen and carbon-14 techniques are the most popular.

Oxygen technique

In this technique, samples are collected from the various depths in bottles with glass stoppers. Some of the bottles are used for determining the concentration of oxygen before the start of the experiment using Winkler technique. The other bottles are again lowered to the depths from where the samples came and kept there for 24 hours in paired light and dark bottles. In the dark bottle only respiration takes

place while in the light bottle both photosynthesis and respiration take place. The oxygen content in the light bottle minus that in the dark bottle represents the *gross* production. The oxygen content in the initial bottle minus that in the dark bottle represents the respiration of all the organisms present. The oxygen content of the light bottle minus that of the initial bottle represents the net community production.

$$\text{Production (mg C)} = \frac{O_2\ (\text{ml}) \times 0.536}{PQ} \text{ or } \frac{(O_2\,(\text{mg}) \times 0.375}{PQ}$$

where PQ (photosynthetic quotient) is taken as 1.25.

Carbon-14 *Technique*

This technique introduced by Steeman Nielson in 1952 is the most suitable technique for the measurement of primary production in water bodies where the rate of production is very low. Besides, the practical application of the technique in field work is relatively simple. A solution with a definite amount (1 ml) of $Na\,H_{14}CO_3$ in sealed ampoules is pipetted out and is added to water samples collected from different depths before an experiment. The total content of CO_2 in the water is determined or estimated. After the exposure of the samples for a definite period either from sunrise to noon or noon to sunset at the same depth (*in situ*) or in incubators with neutral density filters simulating the light conditions of the various depths (*simulated in situ*), the samples are filtered on to Millipore or membrane filters. The filters are dried over silica gel and counted in a Geiger-Muller Counter. The counts are converted into the carbon equivalent.

$$\frac{\text{Activity of the filter (opm)}}{\text{Activity of the ampoule (opm)}} \times \frac{\text{Total } CO_2 \text{ of water} \times \frac{12}{44} \times 1.06}{\text{hours of incubation}} = \text{mgC}|1|\text{hr}$$

By integrating the values for the different depths production for the water column in $gC\,m^2$ day is calculated.

Factors affecting primary production

The factors influencing primary production in water bodies are the quantity of solar radiation reaching the surface, turbidity which affects light penetration, nutrients and temperature which brings about the regeneration. The grazing

effect of zooplankters also will influence the observed rates of primary production. In our waters, primarily the availability of nutrients is the most important single factor affecting the rate of primary production.

Primary production and fishery resources in the Indian seas

There is great amount of seasonal and spatial variation in the magnitude of primary production in the Indian Ocean. The shelf areas which sustain the bulk of the fish production at present are, on the whole, having a high rate of production. Because of the constant replenishment of nutrients in the surface layers the shallow water areas of the tropics are generally productive. An average rate of 0.5 to 1.0g $C/m^2/day$ is observed in the shallow areas most of the time. Rates exceeding 2g $C/m^2/day$ are found during the southwest monsoon.

In the eastern Arabian Sea, towards the coast of India, the average rate within 50-metre depth is about 1.2g $C/m^2/day$ and for the outer shelf regions the rate is 0.5g $C/m^2/day$. The net production (taken as 60% of the gross) for the shelf area on the west coast of India within 50 metres (114,520 sq. km) has been estimated as 30 x 10^6 tonnes of carbon. Between 50 and 200 metres (168,790 sq. km) the net production is only 16 x 10^6 tonnes. Thus for the whole continental-shelf area on the west coast of India the annual net production is computed at 46 million tonnes of carbon. The rate of primary production for the east coast are 0.63g $C/m^2/day$ on the shelf and 0.19g $C/m^2/day$ outside the shelf and the annual estimate of net production is 15 x 10^6 tonnes of carbon for 1,11,150 sq. km of the shelf. The net production for the whole Indian Ocean has been computed at 3.9 x 10^9 million tonnes.

The magnitude of primary production in the Indian Seas is primarily governed by the availability of nutrients as factors such as light and temperature have no significant bearing. The latter two factors have high variability as in the northern latitudes.

The optimum yield from primary production in intensively exploited waters being 0.4%, the potential yield could be computed as $\frac{0.4 \times 46 \times 10^6}{100}$ = 1,84000 tonnes of carbon = 1.84 million tonnes of fish. The latest figure being 0.9 million tonnes, there is scope for further increasing the present yield.

On the east coast the net production has been estimated at 15 x 10^6 tonnes. This may be an under estimate due to lack of sufficient data. But the shallow areas on the southeast coast being highly productive, it is possible that a higher annual net production could be envisaged. That would amount to 50% of the west coast production or 1 million tonnes instead of the present catch of 300,000 tonnes. Thus the potential harvest for the whole Indian coast is about 3 million tonnes of fish, which is about the yield from the Indian Ocean at present.

The Central Marine Fisheries Research Institute, recently made a quantitative assessment of the potential resources of the Indian Ocean from primary production and zooplankton biomass and examined it in the light of the results of the exploratory fishing conducted at various regions. The net primary production for an area of 51 million square kilometer of the Indian Ocean has been computed as 3.9 x 10^9 tonnes of carbon per year. This is in close agreement to the estimate of Russian Scientists, i.e. 4.1 x 10 tonnes.

An estimate of the possible catch at the present level of world fishing is 11-12 million tonnes.

Laboratory cultures of phytoplankton

The laboratory cultures of planktonic algae have got very important role in the field of marine biology. Unialgal cultures are essential for investigation on cytological, physiological and biochemical characteristics. They are used for solving many problems relating to ecology, growth, propagation, heredity and genetics and also as food for animals under investigation.

Methods of culturing

If a particular organism is to be raised in culture, ascertain its presence in the sample collected. This can be done by examining the sample under microscope after either centrifuging or sedimenting. On securing the desired organism, transfer the sample into a series of petri dishes each containing different enriched media. Keep them exposing to sunlight or artificial light. This preparatory culture is used to select the suitable medium. During this period the organisms multiply and provide enough material for further process of culturing. Attention must be given to remove ciliates at this stage. Pure culures are sometimes obtained only after several attempts. The preparatory cultures may be maintained till pure cultures are obtained.

Vessels made of pyrex glass are usually used for phytoplankton culturing. But from test tubes to concrete tanks may be used, depending on the quantity of the culture required. For most of the investigations Erlenmeyer flasks equipped with inlet and outlet tubes for aeration are used. Glass tubes or Erlenmeyer flasks plugged with cotton provides enough aeration. The vessels should be cleaned well and sterilized in a hot air oven.

Nutrient requirement of algae varies with species. Hence it is desirable to develop cultures based on nutrient requirement of each species. A culture medium must contain adequate quantities of nutrients trace elements, and other growth promoting substances. Besides, it should have suitable salinity and pH. Chelating agents like citrate help the stabilization of trace elements in solution. EDTA (ethylene diamine tetra acetic acid) maintains growth after first division in some algae. To a certain extent soil extract may replace EDTA. The following semi-synthetic culture media are found suitable to most of the planktonic algae:—

MEDIUM-I. *Schreiber solution*

Sodium nitrate	0.1 gm
Sodium acid phosphate	0.02 gm
Soil extract	50 cc
Filtered water	1 litre

The soil extract is prepared by boiling 1 kg good garden soil with 1 litre of distilled water in the autoclave for one hour. After 2 to 3 days, the supernatant liquid is separated into a flask and sterilised in an autoclave at 120°C for 20 minutes. It is advisable to keep the soil extract in refrigerater if the salts had been added.

MEDIUM - II *Miquel's solution*

A	*B*	
20.2 gm Potassium nitrate dissolved in 100 cc distilled water	Sodium acid phosphate	4.0 gm
	Calcium chloride	4.0 gm
	Ferric chloride	2.0 gm
	Conc. Hydrochloric acid	2 cc
	Diluted to 100 cc with distilled water	

To each litre of filtered water 0.55 cc of solution A & 0.5 cc of solution B to be added.

The isolated species are inoculated into the right medium and exposed to suitable conditions of light, temperature and aeration. Increase in cell numbers in such a culture follows a characteristic pattern and following phases can be observed:

1. *Lag phase* — in which no increase in cell numbers
2. *Exponential phase* — cell multiplication is rapid and cell numbers increase in geometrical progression
3. *Phase of decline*
4. *Stationary phase* — cell numbers remain more or less stationary
5. *Death phase*

Harvesting is done at the exponential growth phase. The culture can be maintained either by occasional replenishment with nutrient or by regular subculturing.

16

PRAWN FARMING

by

K. V. George

Prawn-culture methods presently adopted in different parts of the world can be broadly classified into two categories viz., extensive and intensive methods. Extensive prawn farming consists of just holding, growing and harvesting prawns in the impoundments, whereas intensive culture involves selective stocking of the ponds with prawn fry obtained either from natural sources or by artificial breeding, and raising them by careful rearing under controlled conditions.

Extensive method of prawn culture

Many of the tropical countries have developed simple methods of prawn culture. These traditional practices are common in South East Asian countries, particularly in the southwest coast of India, Malaya, Singapore, Indonesia and Philippines, and generally involve trapping of the juvenile prawns that enter the ponds during high tides and allowing them to grow for short periods. The ponds are provided with suitable bunds and dykes with appropriate sluice facilities to regulate the flow of water during the different phases of tide.

The traditional paddy-field prawn culture (chemmeen kettu) in central Kerala is a seasonal operation carried out in the paddy fields adjoining the tidal backwaters and estuaries of Periyar and Pampa rivers. During the monsoon months, June to September, when the water in the fields is almost fresh, paddy is cultivated and during the rest of the year the fields are utilised for prawn culture operations. Soon after the single crop of paddy is harvested in September, these fields are leased out for prawn culture. The lessee of the field carries out the necessary repairs of the bunds and fixes the

sluice gates made of wooden planks to regulate the flow of brackish water into the field. The area of the field varies from half to sixty ha. No selective stocking is made in the fields, stocking being effected by simply allowing the tidal water from the adjoining backwaters containing juvenile prawns into the fields through the sluice gates during high tide. During the low tide, a closely tied bamboo screen is vertically kept at the inner side of the sluice gate in order to prevent escape of prawns when some water is allowed to flow out. The tidal water is let into the field during all high tides and hence there is no control on the number of juveniles stocked. Fishing activities start in December and are generally carried out at dawn and dusk for 7 to 8 days around every full-moon and new-moon period with a close-meshed conical net which is fitted to the sluice gate during low tide.

Penaeus indicus (36%), *P. monodon* (1%), *Metapenaeus dobsoni* (57%) and *M. monoceros* (6%) are the principal species of prawns obtained from these operations. Very small quantities of fishes such as *Mugil* spp., *Etroplus* spp., *Ambassis* sp., *Anchoviella* sp., *Trissocles* sp., *Muraenesox* sp., *Scylla serrata* etc are also obtained. The annual production of prawns is about 900 kg|ha.

Low-lying fields, where the water is deeper and which cannot be used for paddy culture, are used for growing prawns throughout the year. The mode of stocking and harvesting the prawns is similar to that of the seasonal paddy fields.

There are about 4,500 ha of such prawn-cum-paddy fields in Kerala and it is estimated that the overall catches from these fields alone amount to approximately 4,000 tonnes per year.

Attempts have been made by several entrepreneurs to establish this prawn-culture practice in similar areas in Karnataka State but without success.

In the 'Bhasabadha' fishery of Sundarbans in West Bengal, prawns are cultured along with mullets and perches. The deeper portions of the impoundments primarily made for

paddy cultivation along the river banks are utilised for fish culture activities by putting up bunds and fixing sluices to control the tidal flow. Stocking is effected by allowing tidal waters to flow into the fields as done in Kerala. Stocking is done in January-February and harvesting in September-December. *P. monodon* is the dominant species of this fishery.

The prawn culture in brackishwater ponds of Singapore, Burma and Bangladesh are similar to those of Kerala except that the fields are never used for paddy cultivation. In the 'Tambaks' of Indonesia, *P. merguiensis* and *P. monodon* are cultured along with milk fish. In recent years, the extensive method of rearing prawns by natural stocking in brackishwater ponds has been introduced in Louisiana in U.S.A.

In Philippines, the tiger prawn, *P. monodon* is either cultured alone or along with milk fish (*Chanos*) in brackishwater ponds. The fry of *P. monodon,* locally called *'Sugpo'* are collected from the tidal lagoons and backwaters and are stocked in nursery ponds. After attaining some growth (up to 60 mm) they are transplanted to the rearing ponds at the rate of 10,000 numbers per ha, where they attain growth to marketable size.

The advantage of these extensive methods of prawn culture are:

1. No expenditure is involved in stocking the ponds.
2. Artificial feeding is not necessary.
3. No special care is given to the stocks.
4. Maintenance of the ponds is not very expensive.
5. Harvesting can be done without much extra expenditure.
6. Expensive equipments are not necessary.
7. Vast swampy areas can be brought under culture with relatively low expenditure.

The disadvantages are:

1. Environmental factors cannot be controlled.
2. Stocking is indiscriminate — neither the species nor the number stocked can be controlled.

3. Stocking procedure allows entry of predators and undesirable species.
4. Productivity is low and the yield fluctuates widely.
5. Total harvesting is not possible as it is difficult to drain the ponds completely.

Even in the traditional practice, the prawn production can nevertheless be increased by additional stocking of desired species collected from the backwaters. Supplementary feeding may perhaps result in better production. Appropriate management measures such as regular destruction of predators and maintenance of water quality also will be helpful. The improved method of prawn culture followed in Philippines can be adopted in other countries. By selectively stocking the ponds with fast-growing species such as *P. indicus, P. monodon* and *P. semisulcatus* better returns could be obtained in India also.

Intensive culture of prawns

In intensive culture, the brackishwater ponds are stocked selectively with the early juveniles of fast-growing species of penaeid prawns. The ponds are cleared of all unwanted fish by poisoning with rotenone, tea-seed cake or Mahua oil cake, 15 days before stocking. If the natural growth of bottom algae is poor the ponds are fertilised with organic manure to stimulate a good growth of algal flora. The stocking density is controlled depending on the natural fertility of the pond and the species that is cultivated. In Japan stocking densities up to 20-25 prawns per m^2 are used for culturing *P. japonicus* in disused salt pans with good tidal flushing and with artificial feeding using crushed clam meat. In the U.S.A., for culturing *P. setiferus, P. aztecus* and *P. duorarum*, stocking densities varying from 5 to 8 prawns per m^2 are used in brackishwater ponds with supplementary feeding using pelletised feeds. *P. monodon*, a large species, is usually cultured at stocking densities varying from 1 to 3.5 prawns per m^2.

At Narakkal we found that *P. indicus*, stocked at 5 prawns per m^2 without supplementary feeding grew very fast.

If the stocking density is increased the growth of prawns becomes stunted. The stocking density has to be determined empirically for each area depending on the local conditions. The stocked prawns can be harvested in 5-6 months.

In intensive method of culture, supplementary feeding is usually resorted to in order to increase the yield from the ponds. With supplementary feeding the stocking density could be increased and the growth rate is also accelerated. A good artificial feed should be cheap and at the same time accelerate the growth of the prawns. Various types of pelletised feeds are now being tried all over the world. It is generally believed that the protein content of the feed need not be more than 30%. Vitamins and minerals are added to make the feed more effective. Different types of amino acids and fatty acids have been added to improve the quality of the feed. Another important aspect of the prawn feed is that the pellets should not disintegrate in the water quickly, so that the prawns could hold the pellet and nibble at it slowly.

In the intensive culture of prawns the desired species could be grown either in monoculture or in polyculture with other species of prawns. Prawns could also be grown in mixed culture with compatible species of fish such as *Etroplus suratensis,* mullets and milkfish. For milkifish, multiple stocking and repeated selective harvesting of large fish has been advocated to increase the yield from the ponds. Similar stock manipulation can be tried with prawns also.

Control of diseases

In intensive culture, bacterial, fungal and virus diseases are likely to cause large-scale mortality. Preventive measures should be taken against this risk. If the water in the pond is clean and well oxygenated the danger of epidemic diseases is minimised. Draining the pond after a harvest and allowing it to sundry also reduces the risk.

Management of prawn farms

The success of prawn culture depends to a great extent on the efficient management of farms. The latter involves

preparation of ponds, proper maintenance of bunds and sluices, stocking and population management, supplementary feeding, pest and predator controls etc.

Ponds are to be kept ready for stocking by eradicating predators and other unwanted animals. The bunds should be strengthened properly. Periodical maintenance of bunds are also to be taken care of. Otherwise, water seepage and even breaches of the bunds may occur which will adversely affect the stock. Sometimes crabs and other burrowing animals may make holes through the bunds. This will lead to heavy loss of the stock and damage to the ponds. The sluice gates of the pond are carefully manipulated to control the inflow and outflow of water. The screens should be always kept clean to allow free flow of water. The optimum level of water in the pond should be maintained by proper control of sluice shutters. Poaching can be prevented to some extent by keeping branches of twigs inside the ponds. This will obstruct the use of fishing implements. The predators should be removed periodically in the course of culture operations by employing different types of fishing implements. Appropriate feeding schedule has to be followed to increase the production rate.

17

HARVESTING AND MARKETING OF CULTURED PRAWNS

by

M. Kathirvel

Harvesting and marketing are the final phases of a culture operation. The economy of the culture operation depends on the quantity harvested and that of marketing on the quality produced. In the traditional prawn culture practices of

the Indo-Pacific region harvesting is carried out by nets, by bamboo-screen traps, by draining and by hand picking, while the mechanically operated drag nets are employed in the more advanced countries. Marketing of the harvested prawns is done in live or fresh conditions as well as in processed forms.

METHOD OF HARVESTING

I. *NETS*

(a) *Conical bag net*: It measures 6 to 9 m in length with a mesh size of 5 to 12 mm and is fixed to the mouth of the sluice gate by means of a rectangular frame. The net is operated during the low tide when the water is let out through the sluice gate at night time. A light is installed near the mouth of the sluice gate to attract more prawns. The prawns trapped at the cod end of the net are removed periodically. Fishing by this net is carried out for 7 or 8 nights in a fortnight, i.e. 3 or 4 nights on either side of the full-moon and newmoon. This type of gear is extensively used in the traditional paddy-cum-prawn cultivation of Kerala, as well as in the *bheris* of West Bengal in India and in the prawn culture operations in the ponds of Pakistan, Singapore, Malaysia, Indonesia, Thailand and Philippines.

(b) *Pound-net*: It has three elongate, conical-shaped collecting nets (with funnel inside) attached to the wall of the rearing pond (Shigueno 1973). The net is set in the pond with the wing directed to the shore at 90°. This type of net is used at night hours to catch the roaming prawns.

(c) *Pump-equipped drag net*: It is constructed in two parts, a frame and a drag net (Shigueno 1973). The metal-rod frame is in square shape and is fitted with a waterpipe (60-mm diameter) on which a number of nozzles are fixed. The pipe is attached to the bottom of the frame. Water from the boat is led at high pressure through a hose to the waterpipe. The other part of this gear is the conical-shaped drag net which is connected to the rear of the frame. The net is weighted by a tickler chain (9 mm long) to be drawn in front of the ground rope. In operation, the net is towed by

a motor boat at a speed of 20-30 m|minute and the water-pump on the boat passes at a high pressure (4 kg|cm ^{2}(and at the rate of about 0.3 m^3|minute, to the waterpipe of the frame. The water is jetted through the nozzles vertically to the bottom layer of the pond in order to stir up the sand to a depth of 6-8 cm, whereby the prawns are scared out and eventually trapped in the net. This gear is specially designed to trap the prawns during day time when the prawns tend to burrow in sand and become inactive.

(d) *Electric-shocker*: This is very similar to the above mentioned pump-equipped drag net in having the metal framing and a drag net. But instead of the nozzled pipe there are brass bar (12 cm long and 12 mm wide) situated 20 cm apart, from the bottom of the frame (Shigueno 1975). The brass rods are positive and negative electrodes and are arranged alternatively. The wiring is insulated against water. The battery, volt meter, ampere meter and switch-board are all kept in the boat. In operation, the current from the battery is charged to the electrodes in the frame, which touch the bottom, shocking the prawns in the sand and the prawns leap up and are trapped by the drag net.

(e) *Cast and drag nets*: These nets are employed in the final harvesting when the water level is very low.

The pump-equipped drag net, pound-net and electric-shocker are used in harvesting of *Penaeus japonicus* in Japan.

II. *TRAPS*

Bamboo-screen trap: In Philippines there are three types of this gear (Delmendo and Rabanal 1956) commonly used in the capture of *P. monodon*. Generally it consists of a guide screen or leader and a catching chamber. In the first type (locally called as 'bakikong' type) the leader consists of one or two bamboo screens staked and oriented perpendicularly or diagonally from the pond dike. This leads the prawns to the fore chamber from which the prawns are led into the catching chamber. A light is installed in the catching chamber at night to attract more prawns. This type is more

effective during the darker nights when there is tidal movement in and out of the pond. The second one, which is called as 'paabang' type, consists of a catching chamber located centrally and 2 wings to screen the water passage. This trap is so effective in trapping prawns at some narrow gap in the culture pond where the strong current exists. The third type known as 'aguila' slightly modified from that of 'bakikong' type is having a longer leader screen and two chambers strategically situated at both sides at the end of the leader. This trap is set in the deeper region of the pond and the continuous fishing can be done both during day and night and irrespective of the regulation of tidal flow.

SIZE OF PRAWNS AT HARVEST

The size of prawns at harvest is the important factor which determines the price of the prawns. Among the species considered for culture operations, *Penaeus indicus* is known to grow up to a size of 230 mm, *P. monodon* to 337 mm, *P. semisulcatus* to 250 mm, *J. japonicus* to 270 mm, *Metapenaeus doboni* to 125 mm, *M. monoceros* and *M. affinis* to 180 mm. In traditional culture operations the size of larger prawns at the time of harvest varies from 120 to 150 mm in *P. indicus*, 50 to 60 mm in *M. dobsoni,* 65 to 75 mm in *M. monoceros* and 40 to 50 mm in *M. affinis*. It is found that *Penaeus* spp. grow at a faster rate in their postlarval and juvenile phases and attain a marketable size of 130-150 mm (20-22 grams in weight) in about 6 months. In the case of *Metapenaeus* spp. the marketable size being 60 to 70 mm (3 to 5 grams in weight) is reached within 6 to 9 months. Since there is a great demand for larger prawns, profitable harvesting can be achieved by culturing those prawns which grow fast and whereby attain a size of at least 130 mm in the case of the larger species and 60 mm for the smaller species.

TIME FOR HARVESTING

The size attained by the cultured prawns depends on the time elapsed during the rearing period. For example, the

postlarvae of *P. monodon* measuring 15 mm in total length (0.025 gram by weight) grow to a size of 142 mm (weighing 22 g) in 6 months and to 230 mm (95 g) in 1 year in the culture ponds of Philippines. However, the lengthening of the rearing period may not be feasible as it is involving more cost towards the maintenance of the culture pond. In Taiwan, when cultured along with the milkfish (*Chanos chanos*), *P. monodon* is harvested two times in a year and the rearing period lasts only 3 months during which time it attains a weight of 40 g. But if it is cultured alone, the harvesting is possible once in a year only and the prawn weighs 20 g after rearing for 5 months (Shen 1976). In the traditional prawn culture operations the harvesting is carried out many nights in a fortnight resulting in the capture of few larger and more smaller prawns. As the demand for smaller prawns is relatively less, this type of harvesting becomes less profitable. Recent experiments conducted by the Central Marine Fisheries Research Institute with a view to improve the existing practises of paddy-cum-prawn cultivation of Kerala have indicated the possibility of better harvests of large-sized prawns by short-term culture of 1-2 months. (George *et al* 1968).

MARKETING OF CULTURED PRAWNS

In the traditional prawn-culture operations, the prawn catch is sorted out specieswise as well as sizewise. The larger prawns are sold to the freezing companies by auctioning and are exported in frozen or canned condition. The smaller prawns purchased by the local merchants are sun-dried and mostly exported. In Japan, *P. japonicus* cultured are sold in live condition for making the famous Japanese dish 'tempura'. For this purpose, the prawns are chilled to 12°C so as to reduce their metabolic rate on the basis of oxygen in the water trapped in their gill chambers. The chilled prawns are packed in cedar sawdust. Due to the fine insulating properties of sawdust, further refrigeration is not needed up to 48 h in summer and 96 h in winter. On arrival at market site, the prawns are revived by keeping them in warm sea water, and are sold live.

GENERAL REMARKS

The use of different gears such as bag nets, bamboo-screen traps, cast and drag nets in the traditional prawn culture practices are not so effective for the successful harvesting. This is mainly due to the burrowing behaviour of some of the cultured prawns. Ineffective capture of *P. monodon* in the culture ponds of Philippines has been reported to be due mainly to non-gregarious and burrowing habits of the prawn. Similar fishing difficulties are encountered in case of *P. japonicus* also. But in the modern culture of *P. japonicus*, the newly designed pump-equipped drag net and electric-shocker have overcome this difficulty. It is suggested that an increase in the yield of *P. japonicus* can be achieved by stocking of the same size prawns, as mixed size groups do not yield satisfactory harvest (Shen 1976). Recent experiments conducted in Japan (Dehimaru and Shigueno 1972), United States of America (Balazs *et al* 1973) and United Kingdom (Forster and Beard 1971) have shown that higher growth rate of cultured prawns as well as reduction in harvesting period can be achieved by the use of artificial feeds as supplementary food.

References

Balazs, G. H., E. Ross and C. C. Brooks. 1973. Preliminary studies on the preparation and feeding of crustacean diets. *Aquaculture*, 2: 369-377.

Bardach, J. E., J. H. Ryther and W. O. McLarney. 1972. Shrimp culture. In Aquaculture — The Farming and Husbandary of Freshwater and Marine organisms. John Wiley & Sons Inc. New York, p. 587-632.

Delmendo, M. N. and H. R. Rabanal. 1956. Cultivation of Sugpo (Jumbo Tiger Shrimp) *Penaeus monodon Fabricius.* in the Philippines. *Proc. Indo-Pacif. Fish. Coun.*, 6 (3): 424-431.

Deshimaru, O. and K. Shigeno. 1972. Introduction of the artificial diet for prawn *Penaeus japonicus. Aquaculture*, 1: 115-133.

Forster, J. R. M. and T. W. Beard. 1971. Growth experiments with the prawn *Palaemon serratus* Pennant fed with fresh and compounded diets. *Fish. Invest. Minist. Agric. Fish. Food., London, Ser.* 2, 27 (7): 1-16.

GEORGE, M. J., K. H. MOHAMED AND N. N. PILLAI. 1968. Observations on the paddy-field prawn filteration of Kerala, India. *FAO Fish. Rep.*, 57 (2): 427-442.

GOPINATH, K. 1956. Prawn culture in the rice fields of Travancore-Cochin, India. *Proc. Indo-Pacif. Fish. Coun.*, 6 (3): 419-424.

SHEN, T. P. 1976. Shrimp culture. In Aquaculture practices in Taiwan. Fishing News Books Limited, England, p. 111-122.

SHIGUENO, K. 1973. Problems of prawn culture in Japan. In Coastal Aquaculture in the Indo-Pacific Region, Fishing News (Books) Ltd., London, p. 282-312.

——— 1975. Shrimp culture in Japan. *Assoc. Internl. Tech. Promotion,* Tokyo, Japan, pp. 153.

MEMBERS OF FACULTY AND PARTICIPANTS OF THE SUMMER INSTITUTE.

Sitting (L to R): S|Shri R. Reghu, R. S. Pandey, N. Neelakanta Pillai, N. Surendranatha Kurup, M. S. Muthu, K. H. Mohamed, Dr E. G. Silas (Director), Dr P. Vedavyasa Rao, S|Shri K. V. George, C. Suseelan, M. Kathirvel, C. P. Gopinathan, A. V. Kulkarni.

Standing (L to R): Dr K. S. Pandian, S|Shri S. Shanmugham, P. B. Tandel, P. Muthiah, K. S. Joseph, V. Venketesh, Y. A. Trivedi, Mohmood Syed Faheem, M. I. Patel, K. M. S. Ameer Hamsa, P. C. John, B. Venketesh, M. S. Sivaraman, P. Karunakaran Nair, K. Arumugam.

Mathrubhumi, Cochin-17, India.